Engineering News

VOLUME 74 DECEMBER 30, 1915 NUMBER 27

Concrete-Lined Reservoir at Salt Lake City, Utah

By Sylvester Q. Cannon*

A reinforced-concrete lining without expansion joints is the chief feature of the 5,000,000-gal. Pleasant Valley distributing reservoir recently completed as a part of the water-works of Salt Lake City, Utah.

The reservoir is located in City Creek Cañon, about 1½ mi. from the city hall. In plan the reservoir conforms practically to the outline of an old pond. It is chiefly in excavation, but on the south side (left side in the view) there is an embankment built years ago. The inner slopes are 1 to 1 and the water depth is 21 ft.

The floor, or bottom lining, consists of a two-course pavement with a base of 1:2:4 concrete 5⅝ in. thick and a top of 1:1½ mortar ⅜ in. thick. The slope lining consists of one-course concrete 1:2:3½ mixture 6 in. thick, painted with two coats of neat-cement grout. Reinforcement consists of ½-in. twisted steel bars, 12 in. c. to c. lengthwise and 24 in. c. to c. crosswise of the reservoir. The per cent. of reinforcement is 0.35 longitudinally and 0.17 transversely. The slope lining was laid in horizontal sections 4 ft. high. A drain pipe of 4-in. tile was laid around the base of the reservoir.

REINFORCED-CONCRETE LINED DISTRIBUTING RESERVOIR FOR WATER-WORKS OF SALT LAKE CITY, UTAH

The total cost of the reservoir, including valve house, outlet and intake pipes, was $18,720, or $3,744 per 1,000,000 gal. The unit prices were: Excavation, $0.45 per cu.yd.; concrete in the floor, $1.58 per sq.yd., including reinforcement; concrete in slopes, $1.74 per sq.yd., including steel. The contractor was P. J. Moran, Inc.

Upon filling the reservoir the first time, a slight leakage developed which was found to be mainly due to some small cracks that occurred in laying the floor over a section of the ground containing some surface water.

*City Engineer, Salt Lake City, Utah.

Low Concrete Dam at Harrisburg Across Susquehanna River

By Joel D. Justin*

SYNOPSIS—Long concrete dam built mainly to abolish nuisances due to stagnant water. Creates 4-ft. pool and offers no impediment to occasional high water. Unique design, especially in use of precast concrete beams for deck of dam. Construction of piers carried out in novel fashion. Cheaper than similar temporary timber dams.

Many timber crib dams have in the past been built across the shallow Susquehanna. The cost of such dams has averaged from $50 to $80 per lin.ft., the length of the dams frequently exceeding one-half mile. Of course such structures are not of a permanent nature. The City of Harrisburg last year completed the construction of a permanent reinforced-concrete dam 3,139 ft. long across the Susquehanna River at an approximate cost of $75,000, or $24 per ft. The height of the dam varies from 5 to 9 ft.

The Susquehanna River at Harrisburg is a wide, rapid stream flowing over an irregular limestone formation. In most places it is quite shallow, except in times of floods. The limestone stratum forming the bed of the stream is broken in many places and contains very large cavities which are found filled with the products of erosion—boulders, gravel, sand and clay.

Reasons for Building the Dam

Until the completion of the intercepting sewer along the river bank, lateral sewers at practically every street location in the densely populated portion of the city discharged into the river. This sewage, together with the filth and culm carried by the river, was deposited along the shore during the low-water period in the summer time. To make matters worse, the contour of the shore was such as to cause numerous pools of stagnant water to form at that season of the year. The unsightly and odoriferous condition of the shore line can be well imagined. The odors arising from the shore line were very objectionable to residents along Front St., which parallels the river, and were also a source of constant annoyance to pedestrians on the park paths at the top of the river bank. The stagnant pools along the shore line bred countless mosquitoes that made the sojourn of visitors in the park along the river bank anything but pleasant.

Investigation showed that by raising the low-water stage of the river 4 ft. the stagnant pools could be done away with; and the velocity along the shore line would be sufficient to prevent the deposition of filth and would thus do away with the objectionable odors. Accordingly it was as a sanitary measure that the construction of a low dam across the Susquehanna River was first agitated, and in 1901 by vote of the people the sum of $65,000 was appropriated to build the dam as a part of the improved sewerage system of the city. At the 2.5-ft. stage of the river, which is the average low-water stage, the mean velocity of the river is about 1½ ft. per sec. With the dam in place it is about 1 ft. per sec. This velocity with the dam in place is, however, much more evenly distributed, as the dam does away with many riffles. Pleasure boating on the river opposite Harrisburg, which before the construction of the dam was little indulged in, will now undoubtedly become very popular.

After the money had been obtained, it was found that although the city had obtained the approval of the project by the State Water Supply Commission, there were legal difficulties in the way of the city's building a dam. The city solicitor gave it as his legal opinion that the Board of Public Works had no right to go ahead and construct the dam without obtaining express authority from the State Legislature.

People in the lower end of the city and in the adjoining borough of Steelton were strongly opposed to the building of this dam, believing that it would cause ice jams and floods that would sweep away the lower end of the city. The utter absurdity of the contention that a dam which raises the low-water stage 4 ft. would have any effect on the height of a 20-ft. flood is at once apparent to engineers. As a matter of fact, the dam is drowned out at a 10-ft. stage. A legislative committee, however, is far more prone to heed the testimony of the "old riverman" who has rafted on the river for 40 years and remembers the Johnstown flood than to the testimony of the engineer who comes down from New York and makes an investigation and a report. Accordingly it was not until February, 1913, that the city was able to get the special legislation allowing it to construct the dam.

In the meantime an intercepting sewer that passes the sewage below the dam site had been built along the bank. Accordingly the main function of the dam is to do away with mosquito-breeding pools and to provide a stretch of the river about 3 mi. long for boating. Its construction also cheapened, to the extent of $50,000, the design of the stepped reinforced-concrete retaining wall which was built at low-water mark along the river for a distance of 2½ mi. (described in *Engineering News*, July 22, 1915).

Design Features of the Dam

The dam consists of a series of reinforced-concrete piers 2 ft. thick and spaced 10 ft. on centers. The height of these piers varies with the contour of the river bed from 5 to 12 ft. Each of the piers is anchored to the rock bottom of the river by ten 1-in. bars drilled 3 ft. into the rock and grouted. The upstream slope of these piers is 1 on 2, and the downstream 1 on 8. Top beams 2 ft. 3 in. thick, having a clear span of 8 ft., tie the piers together. These beams contain ten 1-in. square reinforcing bars and are cast in place, the piers being provided with a 6-in. key to receive them. The upstream slopes of the piers are provided with 4x10-in. grooves, one on each side, in which are placed slabs having a clear span of 8 ft. and a total length of 8 ft. 8 in. The slabs are 2 ft. in width and vary from 8 to 11 in. in thickness, according to the depth. They are reinforced with ⅝-in. twisted square bars. The casting of these slabs was done on

*Recently Principal Engineer, Board of Public Works, Harrisburg, Penn. Now at Chippewa Falls, Wis.

shore, and they were placed after the completion of the rest of the work.

Leakage between the bottom slab and the bed of the river was taken up by the use of sacks filled with cement and sand. The design is believed to be very economical for the conditions existing at Harrisburg, as it is possible to do the work without the use of coffer-dams.

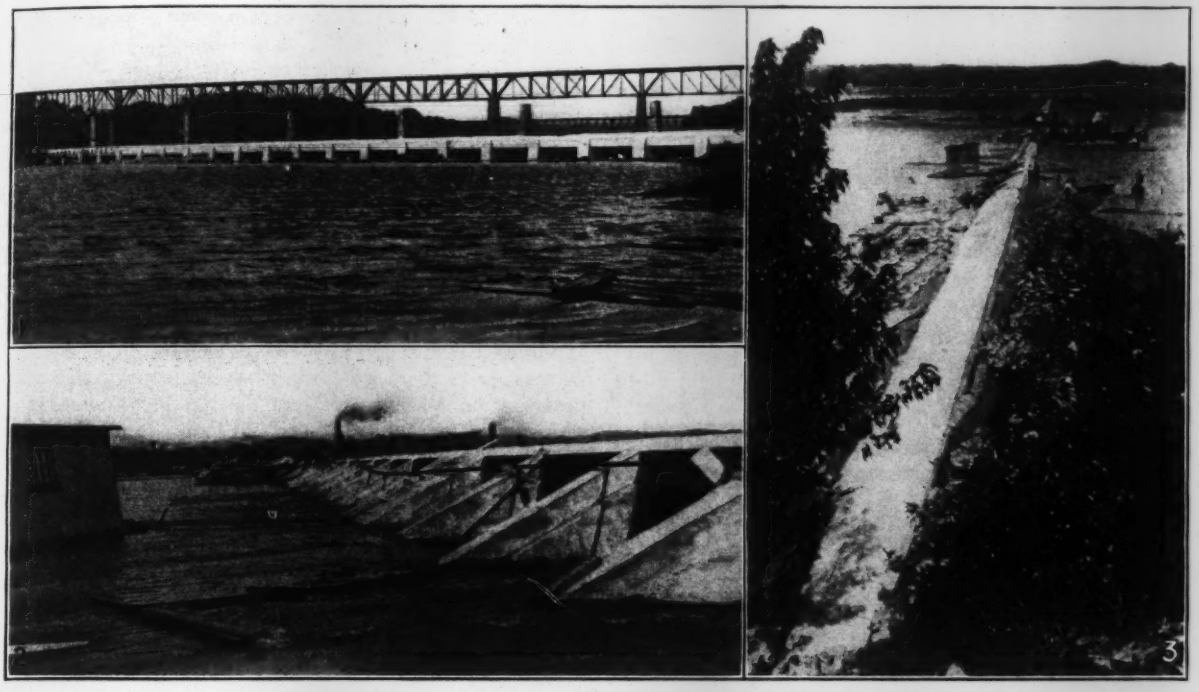
General Methods of Construction

After clearing the site for a pier the contractor set in position a form having neat inside dimensions equivalent to those of the pier at the bottom. This form was then sunk in position and held in place by sand bags piled on the wales. Sand bags were packed around the outside of the forms at the bottom on the rock bed of the river, and frequently sheeting was nailed to the outside of the studs near the bottom to allow of the more ready packing of the sand bags. By taking due precaution in the placing and packing of the bags very little grout was lost. After thoroughly cleaning off the rock inside the form, about 1 ft. of concrete was deposited inside the form through the water.

In depositing this concrete, tremies, either of steel or wood about 8 in. in diameter, were used. The depth of the water through which concrete was deposited varied from 4 to 8 ft. By care in the use of the tremies the washing of the concrete was reduced to a minimum. There was of course some washing, as is shown by the fact that the laitance when removed from some of the footings was found to be 2 in. thick. It is believed that considerable washing was prevented by allowing the concrete to stand on the board from one to two hours before using. At the expiration of this time the concrete was worked over and deposited through the tremies. The mortar of the concrete adhered to the stones better with the "air-set" concrete than with freshly mixed concrete. Both air-set and freshly mixed concrete were tried for this purpose, and it was shown that any decrease in the theoretical strength of the concrete by allowing it to set before using was more than compensated for by the smaller amount of washing with the air-set concrete. As an additional precaution to secure sound, strong footings the concrete was mixed in the proportions, 1 cement, 1¼ sand and 2¼ parts crushed stone. Standard test cylinders made from this reset concrete gave a crushing strength exceeding 2,300 lb. per sq.in.

After the concrete in the footings had hardened sufficiently, it was the intention to drill through the concrete and into the rock and grout in the anchor bars. It was found, however, that the concrete under water hardened so little even in two weeks' time that when drilled it spalled off badly in the 2-ft. piers. Accordingly the contractor used 10 short lengths of iron pipe set in each footing in the required position for the anchor bars. Then after allowing the footing to harden for two or three days the form was pumped out and holes 3 ft. deep were drilled in the rock through the pipes. Owing to the restricted working space (the forms were only 2 ft. wide) "Jackhamer" drills proved to be very convenient in this work. The ten 1-in. square bars of reinforcing steel were then grouted in position. About 1,000 ft. of dam was constructed by this method.

After the anchor bars were in place the pier form, after pumping out, was completed and the remainder of the pier concreted in the dry. The concrete top beam was then formed. Concrete in both top beams and piers was composed of 1 part of cement, 2½ parts of sand and 4½ parts of run-of-crusher stone, maximum size 1 in. The stone was limestone from a local quarry. Although the river contains large deposits of sand, the excavation of which for building and concrete purposes forms a considerable industry at Harrisburg, this local



FIGS. 1 TO 3. COMPLETED REINFORCED-CONCRETE DAM ACROSS SUSQUEHANNA RIVER AT HARRISBURG
Fig. 1—Looking downstream. Fig. 2—Near view of downstream face. Fig. 3—Looking across river

sand was rejected owing to the presence of a large percentage of culm and fine coal. Juniata River sand was used. This proved to be a fairly satisfactory sand, the only thing against it being its poor grading, as is shown by the fact that 80% of it passes a 30-mesh sieve and only 4% a 50-mesh sieve.

Construction Across Island

Throughout a considerable part of the dam the bedrock lay clear of sand and gravel, or was covered by only a few inches. Over this section the method outlined proved to be very economical. About 1,000 ft. of the dam was across an island or sand bar. At this location, after removing the sand, it was here feasible to drill the holes, grout the rods and build the piers without resorting to the method previously outlined, or to the use of coffer-dams. Pumping was of course here necessary.

On other sections where the gravel covering was deeper, the contractor considered it more economical to build sand-bag coffer-dams, generally two bags wide, pump them out, excavate the gravel and build the piers in the dry. In such cases, and also across the island, the slabs of the upstream face were built in place monolithic.

Before construction work was started, soundings were made along the center line of the dam over that portion where bedrock was not exposed. These soundings indicated that where this gravel covering existed it was nowhere more than about 2 ft. deep. When the gravel was excavated it was found that at some locations the rods had struck large boulders lodged in pockets and breaks in the limestone formation. Drills were put down to a depth of 8 to 10 ft. below the bed of the river and no ledge encountered. In such cases excavation was continued below the river bottom only to a sufficient depth to uncover the irregular surfaces of a number of these boulders. A reinforced-concrete footing was then constructed, exceeding the total width of the dam by about 2 ft. It was 18 in. thick at the downstream toe, 12 in. thick at the upstream toe and was reinforced longitudinally with 1-in. square bars spaced 6 in. c. to c.

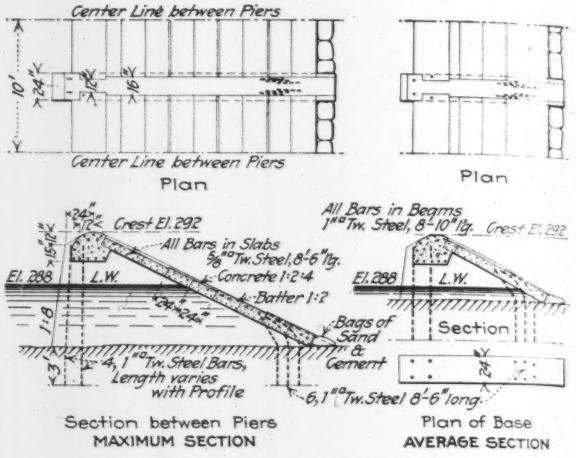
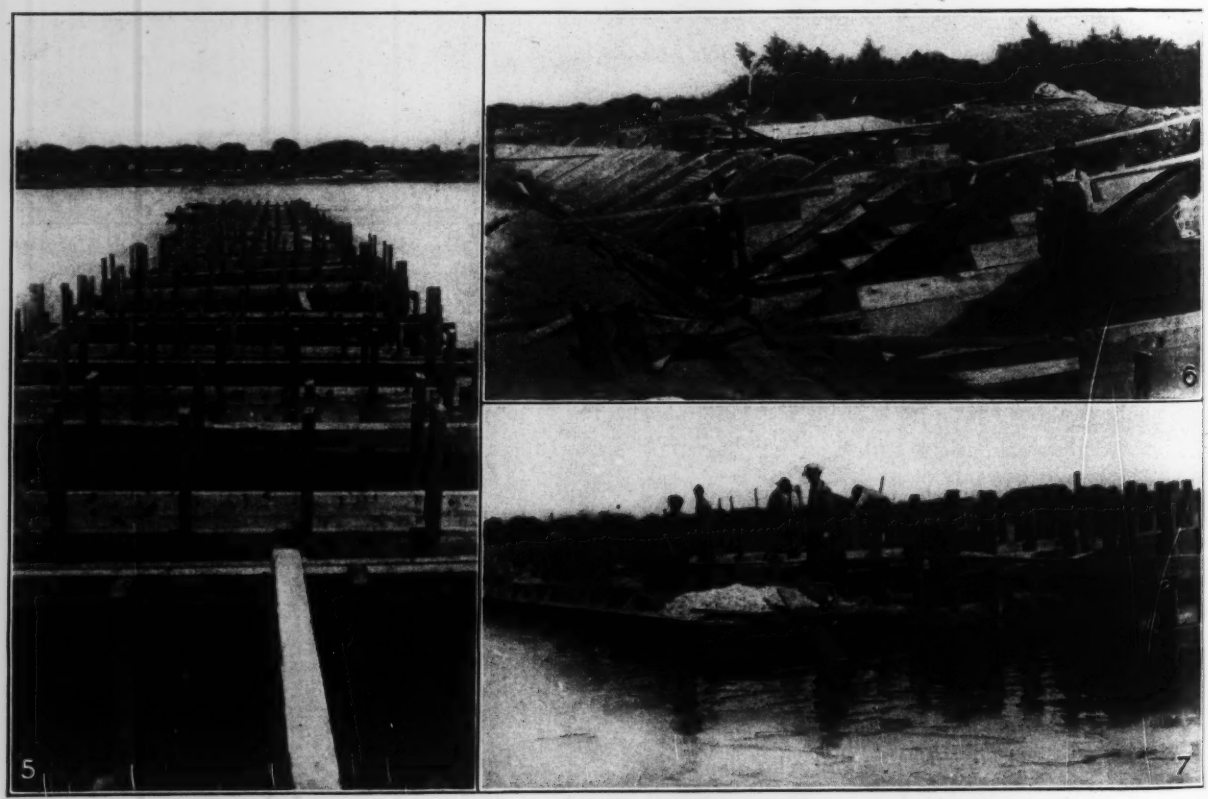


FIG. 4. DETAILS OF HARRISBURG DAM ACROSS SUSQUEHANNA RIVER

at the downstream toe, the spacing increasing to 12 in. at the upstream toe; 1:2½:4½ concrete was here used. In most cases there was projecting ledge rock either just upstream or downstream from the line of the dam, into which the footing was tied by steel and concrete.



FIGS. 5 TO 7. CONSTRUCTION VIEWS OF HARRISBURG DAM

Fig. 5—Pier forms in place. Fig. 6—Piers in place across island. Fig. 7—Concreting footings in river section

These footings were provided with weep holes between the piers. As the minimum width of the footings is 14 ft. and the maximum head on the dam is only 4 ft., it is not considered that water passing under this footing will have velocity enough to move any of the material composing the foundation. The foundation consists of boulders, stones and gravel with some sand. In some cases the interstices are filled with red clay. For these sections coffer-dams were constructed, and the upstream slabs were built in place monolithic. In addition the top beams were built continuous through the piers, and the reinforcement in them carried through continuously. It was found necessary to build 650 ft. of the dam by this method, out of the tofal length of 3,139 ft.

There are two openings in the dam. The one at the extreme eastern end is 33 ft. wide. The opening on the island is 12 ft. wide. The size of these openings is determined by the requirement that at minimum low water there shall be a depth of water over the crest of 0.2 ft. At these openings are three solid sections of the dam, each 10 ft. long. At the western end of the dam the section is very low and is built solid for a distance of 220 ft.

The reinforced-concrete slabs used to form the upstream face of the dam, where not built monolithic, were cast in forms on the bank. After sufficient seasoning they were stored, and after the rest of the work had been completed they were loaded on barges by a stiff-leg derrick, transported to the site and set in place in the grooves by a small A-frame derrick mounted on two scows.

Contract Details and Costs

The contract was let on the unit item basis to Frank M. Skene, of Brockport, N. Y. The prices were as follows:

Reinforcing steel, per ton	$80.00
Concrete (1 : 2½ : 4½), per cu.yd.	20.00
Concrete (1 : 2 : 4), per cu.yd.	21.00
Drilling in concrete and rock, per lin.ft.	.85
Bags of cement and sand, per cu.ft.	.80
Riprapping, per sq.yd.	4.50
Stone filling, per cu.yd.	2.50

No work was done under the last two items. The work required about 2,700 cu.yd. of concrete and 128 tons of steel. Considering the character of the work, the contract prices are not considered high. Only three bids were received, and the successful bidder was also the low bidder.

The work was done under the direction of the Board of Public Works of Harrisburg, with James H. Fuertes, of New York City, as Consulting Engineer; Joel D. Justin, Principal Engineer, and E. W. Cowden, Assistant Engineer in immediate charge of the dam for the city.

Pointers for Comparing Types of Pumping Units

By George M. Peek*

In comparing two types of pumps, such as triple-expansion and turbine-driven centrifugal, careful consideration should be given to other points than the first cost, together with the cost of maintenance and repairs. Some of these matters are discussed in the following paragraphs.

The reciprocating pumping engine may be considered complicated and has many moving parts requiring attention, but it has back of it years of reliable service. This type of pump, when well built and properly maintained and repaired, will be efficient for many years—in fact it would be rather difficult to predict the length of time such a machine will give reliable service.

Another point which should not be lost sight of is the fact that the average operating engineer may be familiar with the details of a reciprocating pump and quite unfamiliar with the operation of a turbine-driven centrifugal. This point is illustrated by an experience with an operating engineer of many years of experience. A motor-driven centrifugal pump was installed in the station where this man was employed, and he reported that it would not work. Upon investigation it was found that, in order to try it out, he had disconnected the discharge pipe—thereby reducing the head to such an extent that when he started the motor it was overloaded and the fuse was blown. He did not seem to understand that no damage would result from closing the discharge valve and letting the machine run at its normal rate of speed.

Nearly, if not quite, all repair work required on a reciprocating pumping unit can be done in a water-works machine shop, whereas in case of a steam turbine it is almost necessary to have the repair work, particularly the rebucketing, done by the manufacturers of the machine.

In general the turbine-driven centrifugal pump has the advantage over the reciprocating pump both in simplicity and first cost. While the turbine-driven pump has not reached the high degree of efficiency reached by the reciprocating, improvements are continually being made, and today its efficiency far exceeds that of a very few years ago. It is impossible to make a comparison between the two classes of machines which would be applicable to all cases, and the problem must be solved for each particular set of conditions.

Cost of Buildings and Boilers; Load Factors

In some general cases where comparisons have been made, considerable charges have been placed against the reciprocating unit on account of the size of the building required to house it. This, in the writer's opinion, should be much smaller than has been suggested by some engineers, for the reason that in many, if not in the large majority, of cases, the water-works is municipally owned. Consequently the architectural effect considered necessary would preclude any very great difference in the cost of the building to house either type of apparatus. Some comparisons do not require the consideration of the cost of a building, since one may be in existence, and therefore the cost is the same for either type of machine.

If it is necessary to install additional boiler capacity, at least 50% in excess of that required for operating the new unit should be installed unless there are sufficient boiler units to allow considerable flexibility for cleaning and repairs. It is quite common in commercial plants to find boilers run at a capacity considerably in excess of their rating, but this is not done in municipally owned water-works.

It is not customary for municipalities to lay by a sinking fund for replacing their equipment, and there should be no amortization charge made against pumping equipment. During its useful life the machinery will have been earning dividends for the taxpayers. Another argument that might be used against it is that it

*Engineer in Charge of Construction, St. Louis Water-Works.

is impossible to say what the cost of replacement would be at the end of the time assumed to be the life of the machine, owing to the market and also to improvements and changes in the type of machinery for the same class of work. The present relative cost of a triple-expansion pumping unit and a turbine-driven centrifugal for the same service may be used as an illustration.

The station load factor will have to be determined for each individual water-works for which comparisons are to be made. Water-works having very small reservoir capacity or pumping into a closed system will have a comparatively small load factor. Water-works having small reservoir capacity will require pumps capable of delivering nearly the maximum demand; and when pumping into a closed system, the pumping capacity must be equal to the maximum demand.

COMPARISON OF ST. LOUIS WATER-WORKS PUMPING UNITS

	Centrifugal Unit	Reciprocating Unit	Difference
Cost of pump	$353,000.00	$103,953.00	$68,653.00
Cost of foundation	2,000.00	2,550.00	550.00
Cost of boilers, including foundation, setting, superheaters, stokers and stack, at $30 per hp.	13,000.00	10,500.00	2,500.00
Total difference in first cost	.....	.....	66,703.00
Annual interest on difference at 5%	.....	.....	3,335.15
Annual fuel cost of steam at 15c. per 1,000 lb.	10,250.00	8,279.20	1,970.80
Maintenance and repairs on boilers at 5c. per 1,000 lb. of steam at capacity	5,694.00	4,599.00	1,095.00
Maintenance and repairs on pumps	550.00	1,500.00	950.00
Annual difference in cost of reciprocating over the centrifugal	.....	.....	1,219.35

Data are based on 60% load factor.

The cost of pumping units and also the cost of maintenance and repairs in the accompanying tabulation are taken from records of the St. Louis Water-Works, where the average load factor is 60%. The machines compared have a capacity of 20,000,000 gal. per 24 hr. against a total head of some 295 ft. The cost of the centrifugal unit includes wet and dry vacuum pumps, condenser, exhaust heater, 42- and 36-in. hydraulically operated gate valves, together with suction and discharge piping inside of the building. The cost of the reciprocating pump includes a condenser, two gate valves, the same as for the centrifugal, together with suction and discharge piping. Tests on the two pumps showed a steam consumption of 10,500 and 13,000 lb. of steam per hr. for the triple-expansion and turbine-driven pumps respectively, for the same work done; the steam pressure was 160 lb. per sq.in. and 100° superheat.

Where the load factor is 97%, there will be no annual difference. It will be noted that the interest rate has been taken at 5 instead of 4%. The interest rate should be that which the taxpayers can realize on their money and not the rate which paid on city bonds.

Progress on Calaveras Earth Dam for San Francisco

The Calaveras dam, which is under construction by the Spring Valley Water Co. to provide additional water-supply for San Francisco, is now about one-third completed. As described in the extended article on the dam in *Engineering News*, Oct. 1, 1914, this dam when completed will be the highest earth dam in the world. The crest of the dam will be 240 ft. above bedrock, and it will contain over 3,000,000 cu.yd. of material. The dam is being constructed by the hydraulic process. The accompanying views, from photographs taken on Nov. 29, show the pool in the center of the dam, into which the pipes carrying the water charged with sand and clay deliver. Besides the material delivered hydraulically, a large amount of material is being placed on the lower slopes of the dam by teams that are loaded by steam shovels excavating from the hillside at the left in Fig. 2.

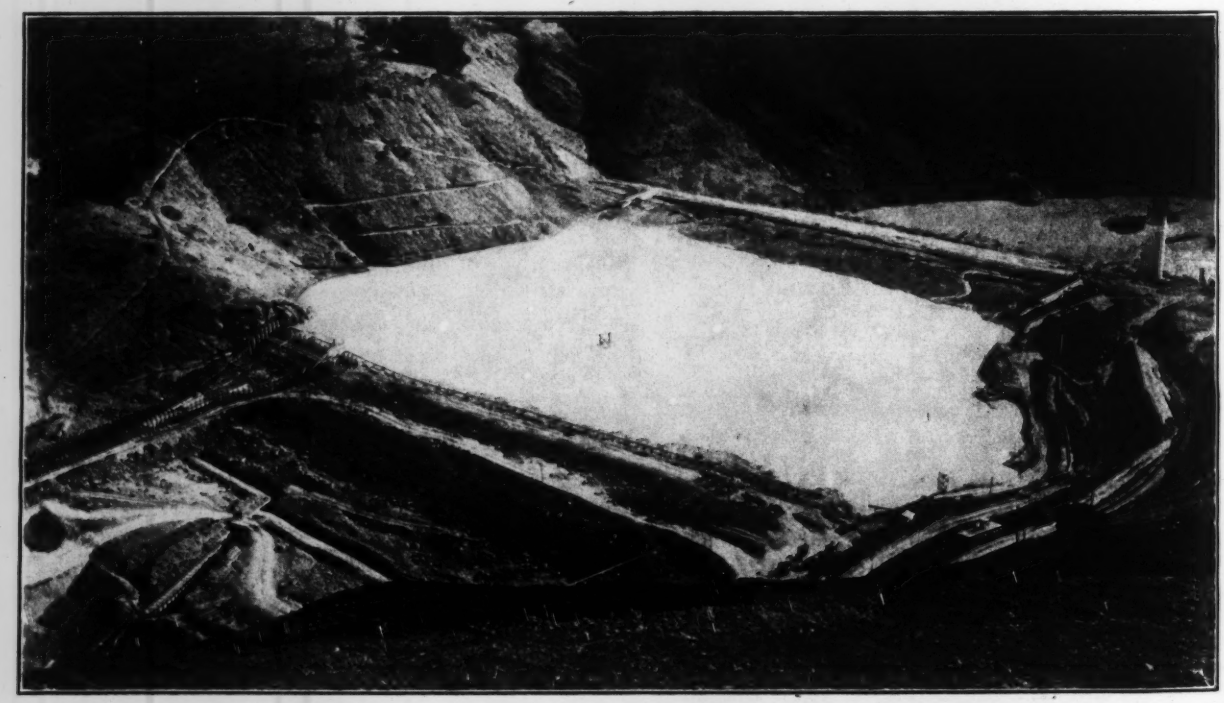


FIG. 1. THE CALAVERAS EARTH DAM FOR THE SAN FRANCISCO WATER-SUPPLY UNDER CONSTRUCTION BY HYDRAULIC PROCESS

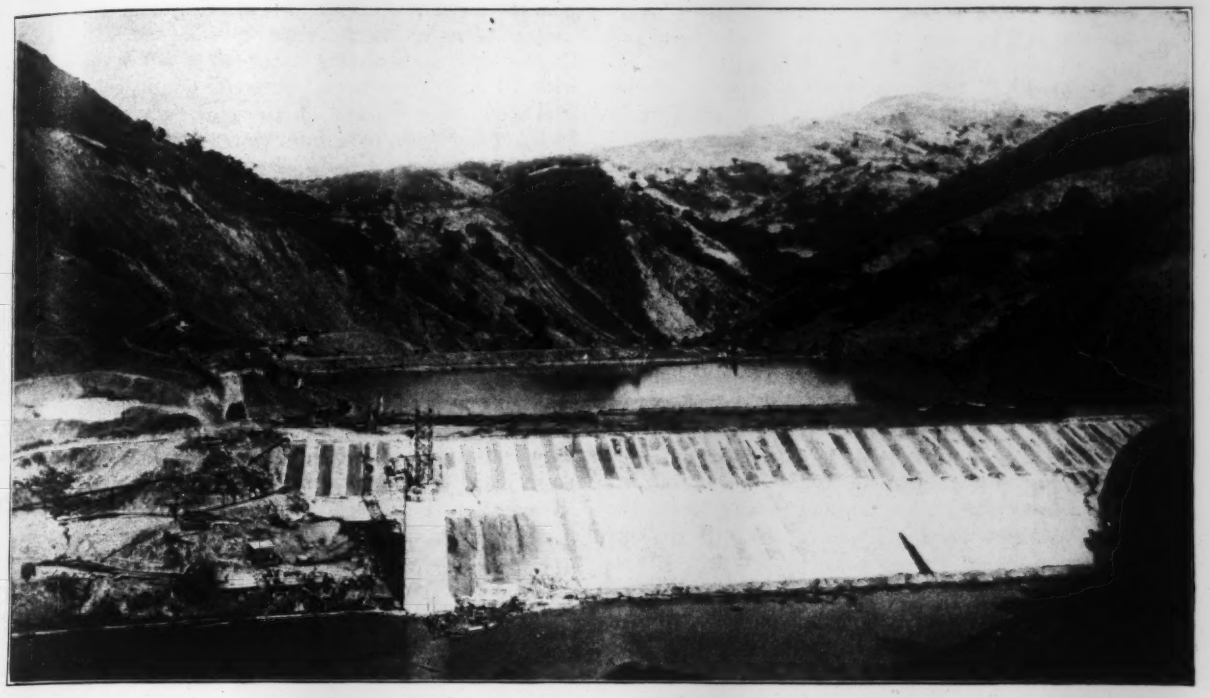


FIG. 2. VIEW OF CALAVERAS EARTH DAM LOOKING DOWN THE VALLEY, SHOWING CONCRETE PAVING LAID IN VERTICAL STRIPS ON UPSTREAM FACE

The engineers aim to keep a large surplus of material at all times deposited on the lower toe of the dam to counterbalance the hydrostatic pressure exerted by the semi-liquid mud in the central core of the dam, which is of course very heavy and which dries out very slowly.

The pressure of the central pool and the mud beneath it against the upper section of the dam will be partly counteracted by the water pressure back of the dam when the reservoir is filled. It is the intention to begin the use of the reservoir for storage purposes during the present rainy season. As may be seen in the views, the upper face of the dam has been paved with concrete to a height of about 80 ft., and the reinforced-concrete inlet tower has been completed to about the same height.

The cast-iron gates to be placed on the tower were ordered from the Rensselaer Valve Co. last spring, and were shipped from New York to San Francisco on a steamer that reached the Panama Canal just in time to be caught in the blockade which resulted from the great slides in October. The steamer was therefore obliged to take the long voyage around South America to reach San Francisco, so that the gates were not delivered at the dam site until the middle of December. While the winter rains have begun in this locality, it is expected that the gates will be placed in time to store a large part of the winter's runoff.

As may be seen from the accompanying photographs, the dam is located in a narrow valley with steep hills rising on each side. Much of the earth on the slopes of these hillsides, however, is not well adapted to hydraulic excavation and placing, and the very large amount of material required for the dam has made it necessary to extend the pipe lines a considerable distance to reach suitable earth. It is estimated that the Calaveras reservoir when completed will increase the available water-supply of San Francisco by 30,000,000 gal. per day. As the present daily consumption of the city is in the neighborhood of 45,000,000 gal., this will provide for its future growth for a considerable time.

The Spring Valley Water Co. is carrying on the construction of the Calaveras dam with its own forces, under the direction of G. A. Elliott, its Engineer.

Present Condition of Second Avenue Test Pavements

By Henry Welles Durham*

An examination was recently made by the writer of the test pavements laid on Second Ave., New York City, in 1912, under the supervision of the Bureau of Highways of the Borough of Manhattan. As these are probably the most varied and extensive tests of city street pavements in this country, brief descriptions of their present condition are of interest. The purpose and extent of the test pavements, with a brief description of each, were published in *Engineering News*, June 27, 1912, at the time they were laid down. The writer's recently issued "Annual Report of the Bureau of Highways" for the year 1914 gives a more complete description and subsequent history to Dec. 31, 1914.

Test Sections of Stone-Block Pavements

The section from the north side of Third St. to the south side of Fourth St. was surfaced with 3½-in. sawed cubes of Medina sandstone, laid on a ½-in. sand cushion and 6-in. concrete base. The blocks were laid with close joints filled with portland-cement grout. The pavement has been in use since January, 1913. The surface is in general smooth, but has developed undulations and many cracks, and at several points considerable areas are

*Consulting Engineer, 366 Fifth Ave., New York City, formerly Chief Engineer, Bureau of Highways, Borough of Manhattan, New York City.

crushed or depressed. Large amounts of repairs have been made each year.

The section from the south side of Fourth St. to the north side of Fifth St. was paved with standard-size Medina sand-stone blocks 3½ to 5½ in. wide, 7 to 12 in. in length and 6 to 6½ in. in depth, with parallel sides and ends, laid with fairly close joints on a 1½-in. sand cushion over a 6-in. concrete foundation. The joints are filled with cement grout as in the cube section, and the work was completed at the same time. The surface of this section has always been rough and uneven, largely the result of poor workmanship in cutting the blocks. The edges of the blocks have held up well, and the poorest condition is the general wavy surface and inferior quality of patching. In any criticism of this section the original poor condition of the blocks should be borne in mind.

These pavements have demonstrated very conclusively, not only the fact that sandstone is not sufficiently durable for the heavy traffic of Second Ave., but also the impossibility of making satisfactory repairs with cement-grouted joints under the conditions prevalent. It is virtually impossible in New York City to keep traffic off repair areas long enough to permit a proper setting of the grout.

From 21st to 23rd St. an experimental section is laid with granite block having a width of from 3½ to 4 in., a length of 7 to 11 in. and a depth of 5 in. Specifications called for joints not exceeding ⅜ in., the blocks to be laid on a ¾-in. sand cushion on a 6-in. concrete foundation. The joints were filled with dry sand to within 3 in. from the top and cement grouted.

The roadway was opened for traffic in November, 1912. The condition of this pavement is only fair. The blocks as originally furnished were not strictly up to specifications, the joints probably averaging in all cases more than the maximum allowance. The cement-grout joint filler has not worn well, many of the joints having opened, and the blocks show wear at the edges. The general surface is uniform except around manhole boxes or where cuts have been made.

Test Sections of Wood-Block Pavement

Between Fifth and Sixth St. Southern short-leaf pine blocks treated with 20 lb. per cu.ft. of a heavy oil having a specific gravity of not less than 1.10 at 38° C. were used. From the south side of Sixth St. halfway to Seventh St. the blocks used were treated with 20 lb. of light oil having a specific gravity of 1.03 to 1.08 at 38° C. From there to the north side of Seventh St. the treatment used was 20 lb. of water-gas tar.

All types were laid on a 1-in. sand cushion on a 6-in. concrete base, the joints being filled with fine sand and the surface thoroughly rolled and finally spread with a thin coating of sand to be rolled in by traffic. The work was completed in January, 1913.

Except for a slight undulating appearance noticeable only on close examination, these pavements are in very fair condition. No difference in appearance is noticeable between the differently treated sections except in extremely hot weather, when there is a slight evidence of oil on the surface of the blocks treated with light oil, but bleeding has practically stopped.

The section from the south side of 13th St. to the south side of 15th St. is laid with Southern long-leaf yellow pine blocks 3x8 in. on the surface and 4 in. deep, on a 1-in. sand cushion over a 6-in. concrete foundation. On the lower part of this section the blocks were treated with 16 lb. per cu.ft. of heavy oil; on the next section 20 lb. of heavy oil, and on the next the treatment was 20 lb. of light oil. The intersection at 14th St. is paved with blocks treated with 16 lb. per cu.ft. of light oil. The next half-block north of this point has paving blocks treated with 20 lb. of water-gas tar, and then there is a section laid with blocks treated with 16 lb. of water-gas tar.

Above 17th St. a section was laid with Southern short-leaf pine blocks measuring 4 in. deep, 3 in. wide and 8 in. long. They were laid on a sand cushion on a 6-in. concrete foundation, and the joints were filled with fine sand. From 17th to 18th St. the blocks used were treated with 16 lb. per cu.ft. of heavy oil, and at the 18th St. intersection 16 lb. of light oil was employed, and from there to 19th St. the blocks used were treated with 16 lb. of water-gas tar.

Nothing in the present appearance of any of these stretches of pavement indicates that under ordinary conditions any variation of treatment of the blocks had been employed. It is only in extremely warm weather that blocks treated with light oil still show slight evidence of bleeding. The entire area is in first-class condition, except around some manhole boxes. Practically no repairs have been required.

At the 17th St. intersection Australian tallowwood blocks were used. This is a hardwood, and the blocks were untreated other than being painted with tar before laying. They measure 4½ in. in width, 3 in. in depth and 8¼ in. in length, and they were laid on a cushion of tar, the joints being filled with paving pitch. The hardwood blocks failed entirely during the first two seasons and have been replaced by yellow-pine blocks treated in accordance with the standard specifications of the Manhattan Bureau of Highways.

Tests of Sections of Asphalt-Block Pavement

A length of three city blocks north of Houston St. is paved with asphalt blocks measuring 5x12 by 3 in. deep, laid on a ½-in. mortar bed on a 5½-in. concrete foundation. The blocks were required to have a specific gravity of not less than 2.45 and a minimum absorption of 1% after seven days' immersion in water. The work was completed in November, 1912. This pavement presents a better appearance in general than the other asphalt-block sections farther north, but is poor along the rails of the car tracks, the space within which is paved with sheet asphalt. As Second St. on the east side there are depressions and waves, as well as at Third St. on the west side, and the east gutter shows many signs of deterioration. A considerable pitting is to be observed over almost the entire area.

A section from 9th St. to 11th St. is paved with blocks made of natural bituminous limestone rock. The blocks measure 8¼ in. long, 4 in. wide and 2⅓ in. deep, with a minimum weight per block of 6 lb., laid on a ½-in. mortar bed on a 5½-in. concrete foundation. This pavement was opened to traffic in November, 1912. Under traffic the blocks have rolled together so that the joints are barely discernible. The general appearance of the surface is similar to sheet asphalt but somewhat more wavy, and where the joints can be distinguished they

show evidence of having traveled in the direction of traffic. Below Tenth St. this section is in better condition than north of that point, probably due to the less intense traffic encountered.

The two blocks from 15th to 17th St. were paved with asphalt blocks made under practically the same specifications as those used in the first section noted, except that there was an attempt made to get a block more suitable for heavy traffic, and the maximum absorption was reduced to 0.6% after seven days of immersion in water. The blocks measured 5x12 by 3 in. deep, laid on a ½-in. mortar bed on a 5½-in. concrete foundation. The roadway was opened to traffic in November, 1912. The general appearance of this pavement shows considerable waviness. The car-track area was paved at the same time and of the same material. Traffic has worn continuous ruts, adjacent to the rails. Near 16th St. on the east side waves are very apparent, and there are some depressions.

Test Sections of Sheet-Asphalt Pavement

The two blocks from Seventh to Ninth St. have an asphalt pavement consisting of a 2-in. wearing surface on a 1-in. old-specification open binder laid on a 6-in. concrete foundation. It was opened to traffic in November, 1912. There is a slight waviness in the surface, but it is otherwise in good condition and up to the first of the present year had required no repairs due to wear and tear. Within the railway track there is also sheet asphalt, but it is the old pavement which extends in this area north from Houston St. Adjacent to the rails some depressions have developed.

The section from 11th to 13th St. has an asphalt pavement corresponding to the more modern specifications of the Manhattan Bureau of Highways, consisting of a 1½-in. wearing surface on a close binder 1½ in. thick, laid on a 6-in. concrete foundation. This section was opened to traffic in November, 1912, and has required practically no repairs. With the exception of some depressions along the rails and around some sunken manhole boxes, the pavement is in fair shape.

From 19th to 21st St. a section was laid with rock asphalt from Ragusa, Sicily, 2½ in. in thickness on a 6-in. concrete foundation. This was opened to traffic in September, 1912. This section entirely failed during the first two seasons, probably owing to the inferior quality of materials and poor workmanship. It was impossible to require repairs in accordance with the original specifications after the outbreak of the European War, and consequently since that time the contractor has done all such work with standard sheet asphalt in accordance with Manhattan specifications.

Street-Cleaning Cost a Factor in Pavement Design

Although treated in some textbooks, the case-of-cleaning factor in the selection of pavements probably receives little consideration in practice. Herewith are extracts from a paper read at the recent Worcester Road Congress by Gus H. Hanna, Commissioner of Street Cleaning of Cleveland, Ohio. In reading them it should be borne in mind that there are many local factors which must be taken into account, and that Mr. Hanna's conclusions are based on experience in one city only. The following paragraphs are substantially in Mr. Hanna's words:

An annual expense of $500 a mile in repairing residence streets would be considered an appreciable item of maintenance, yet that figure for cleaning a mile of residence street through a season is extremely low. A cost of $500 for maintaining a mile of one kind of pavement for a year as against a cost of $1,500 for maintaining another kind would be sufficient grounds, in most cases, to decide in favor of the former material. Yet greater difference than this in cleaning cost is blandly overlooked.

Economy from Street Cleaner's Standpoint

A street cleaner looks for two qualities in a pavement. It must be smooth, and particles of litter must not stick to the surface. The question of smoothness opens up the whole matter of durability. Any material that deteriorates and roughens becomes more difficult each year to clean. Any neglect of needed repairs means a larger cleaning bill until the repairs have been completed.

Additional cleaning expense must be made for all bituminous pavements on account of the sticking of particles of litter to the surface. These surfaces are never quite so clean as nonadhesive materials, and it costs from 25% upward additional to put them in a reasonably presentable condition on account of this quality.

This difficulty is seen at its worst in a new creosoted wood-block pavement, when the oil is gradually working out of the wood. The use of steel scrapers must often be employed, as the flushing by water is not effective at all in removing the dirt from such a surface.

The substances most easily cleaned are brick and stone. Neither of them originates any form of dirt, and both wash off readily. The only ground for discrimination between them as to ease of cleaning is on the question of smoothness, where brick has a slight advantage as a rule.

But in the use of these materials, the choice of a filler is all important. A bituminous filler has all the disadvantages of a bituminous surface, from a cleaner's standpoint, and some others besides. Being softer than the brick or block, it recedes, leaving a crevice that invites the lodgment of dirt. With the edges of the brick or block unprotected, it is sure to roughen, thus adding to the difficulties of cleaning. In fact such a street, after a few years, presents an array of cobble stones, with the filler invisible, or else melted and run to the gutter, where it impedes the work of the follow-up gang.

Some Street-Cleaning Costs

The lowest cost-of-cleaning figure that we have been able to achieve on any type of pavement is 15c. per 10,000 sq.ft. on a 10-yr. old grouted brick pavement. The cost on the best asphalt pavement would be not less than 20c. and would increase to 30c. as the surface became wavy or rough. A wood-block pavement costs practically $1 per 10,000 sq.ft. to clean in its initial condition, and it will be at least two years before the oil will have dried out sufficiently to admit of its being cleaned for 30c. A tar-filled block pavement will cost not less than 30c. per 10,000 sq.ft., and as the filler disappears and the blocks roughen, this cost will amount to 60c. or more.

In the case of a pavement 40 ft. wide, there are about 21 squares (of 10,000 sq.ft.) to the mile. As between a material that can be cleaned for 15c. and one that can be cleaned for 30c., there is a difference of $3.15 per mi. per cleaning, a difference of $15.75 per week, of $630 per season of 40 weeks and of $6,300 in 10 yr.

Laying Submerged Water Mains at Vancouver, B. C.

The entire water-supply for the City of Vancouver, B. C., is brought in submerged pipes across the channels connecting the city's harbor with the ocean. These pipes have been successfully laid under conditions of exceptional difficulty.

The City of Vancouver is built on a narrow peninsula between two arms of the sea. The only possible source of an adequate water-supply is in the mountains which rise to a great height only a short distance north of Burrard Inlet, on the southern shores of which the city lies. As may be seen on the accompanying map, the city's water-supply is taken from Capilano River and Seymour Creek. The water from the former is brought down in steel pipes to the first Narrows just below the city, and the water from Seymour Creek to the second Narrows 5 mi. above.

The tidal range on this coast is from 14 to 17 ft. As Burrard Inlet has an area of several square miles and as the deep channel connecting it with the ocean is only some 900 ft. in width, a tidal current of high velocity, 8 mi. an hour or more, sweeps back and forth through the channel with every rising or falling tide. Almost as rapid a tidal current exists at the second Narrows. The period of slack water in the Narrows is very short, often not more than 20 min. The maximum depth of water is 75 ft. at the first Narrows and 80 ft. at the second Narrows. The channel bottom is very rough and strewn with large boulders on the shore next the city; on the opposite shore is a level stretch of mud flats, bare at low tide.

Early Experience in Pipe Laying

The first pipe laid across the Narrows from Seymour Creek was a 12-in. cast-iron pipe with Ward flexible joints. It is stated that Mr. Ward himself came to Vancouver to lay the pipe, but when he saw the swift current in which it had to be placed, he refused to attempt the job and the pipe was laid by a local contractor, who offered to do the work for a lump sum of $10,000, the city of course furnishing the pipe and the jointing material. He carried out his task with little difficulty and at a cost of only about a third of his contract price. Since then there has not been any difficulty in finding men to do the work.

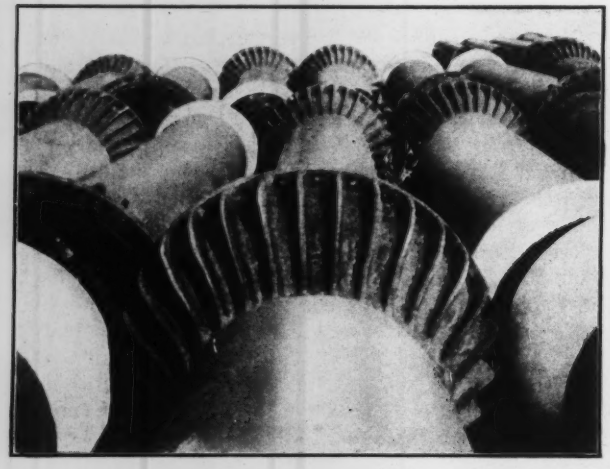


FIG. 1. FLEXIBLE JOINT CAST-IRON PIPE IN WATER WORKS YARD, VANCOUVER, B. C.

FIG. 2. MAP SHOWING LOCATION OF SUBMERGED PIPE-LINE CROSSINGS, VANCOUVER WATER-SUPPLY

When the supply through the first pipe became inadequate, a second pipe was laid, and additional ones have been added as the water consumption increased. The method of laying is substantially as follows: On the flat tidal marsh on the north shore of the river a low wooden trestle is built, extending back from the shore a distance as great as the entire width of the channel, some 1,300 ft. Upon the plank floor of this trestle the pipe is laid, and the joints are leaded and calked. The bell of each pipe length rests on a flat wooden block free to slide on the plank floor, which is greased with tallow.

Hauling the Pipe Across the Channel

After the pipe has been subjected to a hydrostatic test of 300 lb. per sq.in. and any leaks found have been made tight, a hauling tackle for pulling the pipe across the channel is applied. Originally a wire rope was led through the interior of the pipe and secured to the rear end of the pipe line; but the resistance of the front end as it plowed its way across the channel was so much greater than that of the rear part of the line sliding on the floor of the trestle that the pipe line buckled, notwithstanding the tension on the cable inside it. The present practice therefore is to run a couple of hauling cables the length of the pipe line and lash them securely to it at three or four points. To the front end of the pipe line a heavy wooden prow is attached to enable it to plow its way across and take the shocks of contact with ledges and boulders.

When all is ready, a cable is carried from the end of the hauling tackle across the stream and secured to the drum of a hoisting engine on the opposite bank, and the string of pipe is thus hauled across. After the pipe is in place, connections are made at each end and the pipe is again subjected to hydrostatic test. A diver is sent down and calks any leaks which may be found. The diver has a powerful electric light and can readily discover any leaks by the current of sand and dirt raised by the water jet issuing from the leak. The water in the Narrows is remarkably clear, there being only a trifling inflow of fresh water or sewage compared with the vast volume of fresh sea water entering at each tide.

It may be noted in this connection that the Capilano intake is 485 ft. above sea level, and the Seymour Creek lower intake is 465 ft., while "Little Mountain" reservoir, into which the conduits deliver, is 395 ft. above sea level. The maximum head of water on the submerged pipe at greatest depth is about 480 ft.

Maintenance of the Pipes

Once laid and made tight the pipes give little trouble. Dredging which has been undertaken by the Government in recent years to widen the channel on the north side made it necessary to take up some of these pipe lines, and the oldest pipes were not put down again, as it was found that the erosion of the sand carried by the swift tidal current back and forth across the pipe had worn it thin in spots during its 25 yr. of service. It was therefore determined to lay an 18-in. main in its place, and this was done.

This erosion of the pipe could be prevented of course, if the pipe could be buried in a trench across the channel; but the dredging of a trench in 65 ft. depth of water on a bottom strewn with boulders and with the swift tidal current is no easy task. And even if a trench were dug, it would probably be filled by the tidal current before the pipe could be laid in it.

Moreover, the occurrence of any leak in the pipe line is easily detected and repaired by a diver when the pipe line is exposed on the bottom. The city has in fact an expert diver at its command whenever his services are required. The number of lines of pipe laid at the two separate crossings is such that the temporary withdrawal of service of one or more lines for inspection or repairs still leaves the city well supplied.

In recent years all additions to the submerged lines have been made with 18-in. pipe instead of the 12-in. originally laid. In laying this heavier pipe, it has been found better to pull it into place in three separate sections instead of in one line, as was done with the 12-in. After the three sections are in place they are joined by a diver working in about 40-ft. depth of water.

At the first Narrows there have been eleven 12-in. pipes laid; of these, three are still in service. There are two 18-in. pipes, the last of which was laid last fall. At the second Narrows six 18-in. pipes have been laid and are in service (see the view of this in Fig. 3).

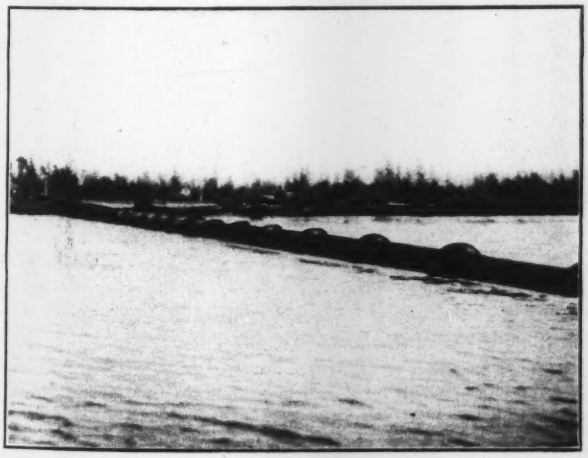


FIG. 3. LINE OF 18-IN. PIPE JOINED UP AND READY FOR DRAWING ACROSS NARROWS, VANCOUVER, B. C.

The flexible pipe used is of the well-known Ward pattern, but has been modified in shape somewhat to reduce the resistance in hauling. A section is shown herewith. This pipe can be deflected 12½° before binding occurs. The pipe is cast in Glasgow and costs $61.50 per long ton delivered at Vancouver. Its weight is about 400 lb. per ft. The total cost of the 18-in. submerged crossings, including the cost of laying, is about $11.50 per lin.ft.

It has occasionally happened that in laying, calking and testing the pipe a bell has been split at one of the joints. Breaks have also occurred from contact with keels

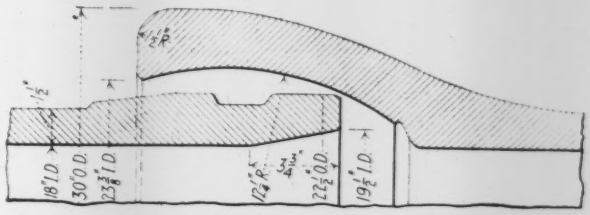


FIG. 4. STANDARD SECTION OF FLEXIBLE JOINT FOR 18-IN. CAST-IRON PIPE, VANCOUVER WATER-WORKS

of ships which have gone ashore in the Narrows during foggy weather. Repairs of such breaks have been effected by placing on the pipe to cover the split a sleeve with a stuffing-box and rubber packing at each end.

Other Descriptions of Pipe Laying

A detailed description of the methods used in laying the 12-in. submerged pipes at Vancouver, written by John Causley, was published in *Engineering News*, May 14, 1908. A description of the laying of the first 18-in. pipe at the second Narrows, written by Mr. H. M. Burwell, at that time engineer of the Vancouver water system, was published in *Engineering News*, Apr. 1, 1909.

The present City Engineer of Vancouver is F. L. Fellowes. We are indebted to Edward M. LeFufy, Assistant Engineer of the Water-Works Department, of Vancouver, for information from which this article has been prepared.

Taming the Rivers for Use—No one can survey the physical condition of the United States without being impressed and almost overwhelmed with the magnitude of the work that must be done in keeping our rivers within bounds and putting them to use. It is the largest task that the Government must undertake sooner or later, and the sooner in my judgment the better. . . . We need to catch the water when it is young, soon after it has been born from the snows. There, in mountain valleys, it should be kept for a time and, as needed, led into the peaceful paths of usefulness. And on that problem the Reclamation Service is working. The difficulty is to find large reservoir areas. The problem extends from sea to sea. When we come eastward, to the Missouri and the Mississippi for example, we find that in their upper reaches the lands need the waters, while in their lower reaches the lands must be saved from the waters. . . . . How these great works can be carried on calls for constructive thought, not merely on the engineering side, but more immediately upon the financial side as to those ways and means by which the lands reclaimed shall be made to bear in some degree the burden of the expense. As to the funds which will be needed, they mount into such figures as to be staggering. And I can see no hope that this work will be adequately undertaken without the Government advancing its credit and investing directly some of its own funds. A commission to devise the ways and means by which the states and private land owners and the national government can coöperate in paying for the work done seems to me a more needed body than one which will report upon engineering methods.—From the annual report of Franklin K. Lane, Secretary of the Interior.

Steel Framing of a Large Power Station

SYNOPSIS—Careful design shown by low figure of weight per unit of floor area. Switch house designed for only one arrangement of apparatus. Boiler house specially braced for stack wind pressure. Intermediate posts under bridge walls of furnaces. Special roof framing. Turbine house columns carry 100-ton crane.

The new Essex generating station of the Public Service Electric Co., Newark, N. J., has a number of notable features in its steel framework. It is a 50,000-kw. station at present and will later be extended to an ultimate capacity of 200,000 kw. The designers claim that the steel weight per unit of floor area is some 20% less than that of any other large steam station.

The ground-plan area of the buildings is 45,450 sq.ft. and the inclosed volume of the plant is 4,338,000 cu.ft. The total weight of steel is 3,800 tons, which includes the weight of the steel in the stacks, in the coal bunkers outside of the boiler house, in the framing for the ash pocket and in the coal-tower framing and support up to the top of the bunkers. The weight excluding stacks but including the steel for stack supports—an integral part of the boiler-house framing—is 3,475 tons. Taking the total steel weight, the unit weights are 0.765 ton per 1,000 sq.ft. of ground area and 0.79 ton per 1,000 cu.ft. inclosed volume.

The plant comprises three buildings—boiler house, turbine house and switch house, of which the first two are contiguous, while the switch house is separated from the turbine house by a 25-ft. alley. The boiler house and turbine house are designed for extension by adding successive units. Each unit consists of four boilers and one 25,000-kw. turbine. The layout is such that 35,000-kw. or larger units may be installed without changing the scheme. All future extensions are made on the rear or landward side. The coal bunker, coal tower and ash pocket are housed in a steel structure built outside and parallel to the boiler house on the end opposite the turbine house, and the bunkers are to be increasd by duplication, a separate bunker for each firing aisle (for four or eight boilers, as the case may be). The coaling tower will serve all the bunkers. In this tower only one engine and a hoisting equipment are installed at present; it is designed for two in the future.

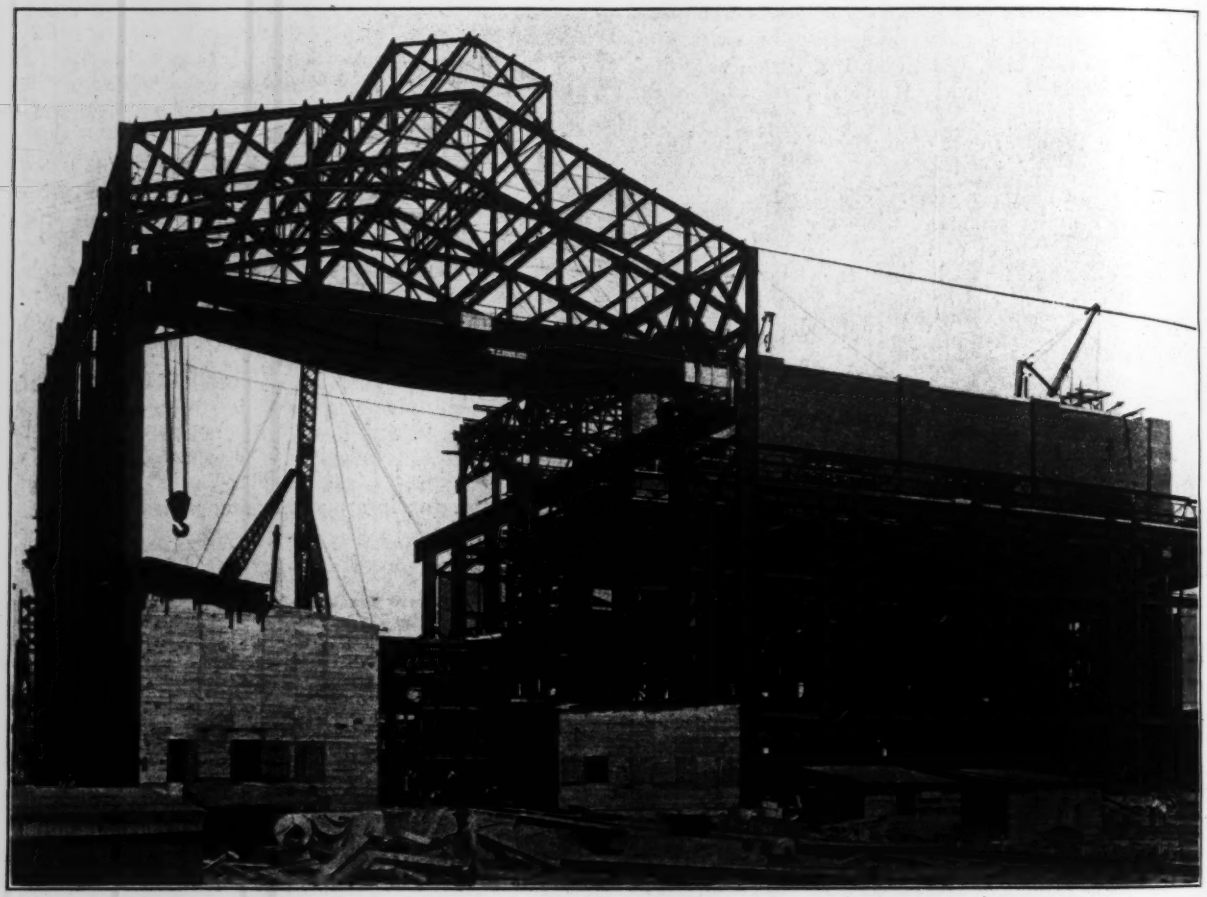


FIG. 1. PARTLY ERECTED TURBINE HOUSE; BOILER HOUSE AT RIGHT, SEEN FROM SOUTH

The switch house is a six-story tier building, and its column and floor framing are of the usual tier-building type. Two features invite notice—(1) the use of box columns, in contrast to the I-section now popular in tier-building work, and (2) the fact that all parts of the Elsewhere in the top story the same roof outline is maintained, but column-and-beam construction is employed, as columns are not objectionable here.

The turbine house is of typical single-bay mill, or erecting-shop, style, comprising two rows of columns,

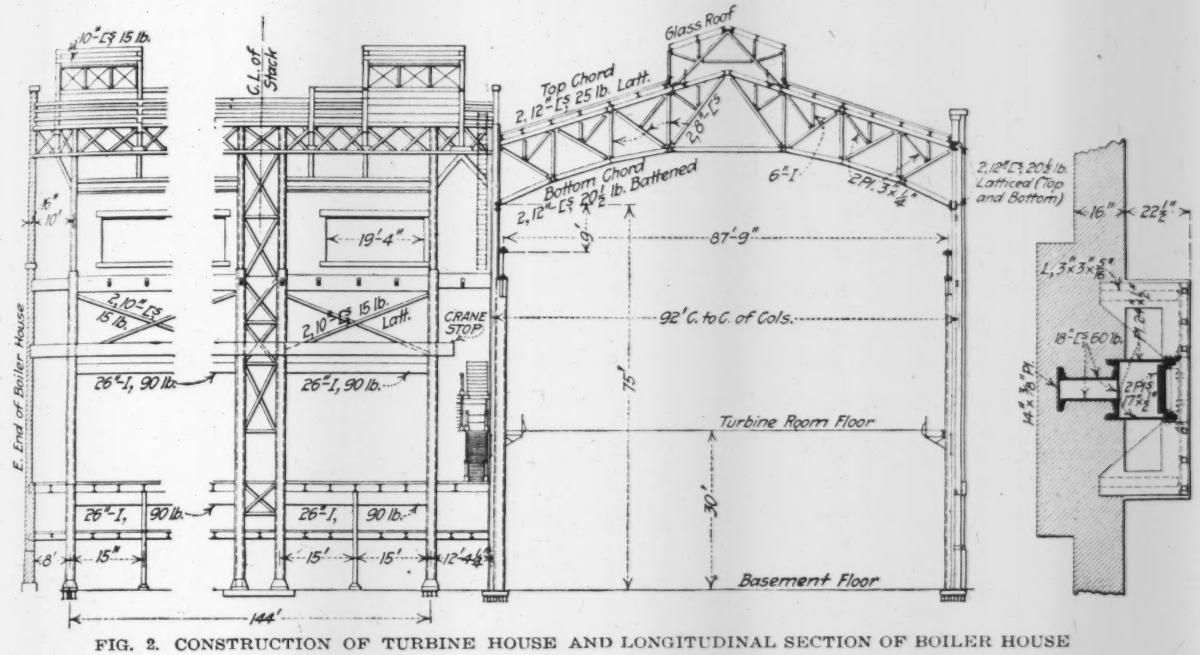


FIG. 2. CONSTRUCTION OF TURBINE HOUSE AND LONGITUDINAL SECTION OF BOILER HOUSE

framing, each girder and each beam, were designed for the exact load coming upon them in the particular arrangement of apparatus laid out. The designers took the view that the arrangement of switches, boards and other apparatus is not likely to be altered a great deal later. A certain allowance was made, however, for possible variations. As the beam and column spacing was laid out to the best arrangement for the present installation, reconstruction of the floor beams might be necessary in case of any material change in arrangement or equipment.

Because of designing for actual loads, the various panels of the floors are of widely differing capacities, ranging from 150 lb. per sq.ft. to 450 lb., equivalent uniform live-load.

The floor filling in the switch house is reinforced-concrete slab construction throughout. The slab rests on top of the I-beams, so as to make its whole depth available for containing the electrical conduits. The necessity of accommodating a great many such ducts, mainly for the control wiring, affected the thickness of slabs selected. The thickness varied according to the amount of conduit—the number of layers—and ranged from 4 to 10 in. Thus in the switch rooms a 7-in. slab was adopted, in the control gallery (sixth floor) 5 in., in the conduit room (fifth floor) 10 in., and in other floors down to 4 in.

The switchboard room, or control gallery, contains a novel switch-panel arrangement, partly circular and partly straight, partly panel board and partly bench board, with indicating instruments on the back. This control gallery is roofed with trusses spanning the center bay of the building and framing into steel girders. From the under side of the girders trussed steel beams are suspended, to which an ornamental ceiling is attached. roof trusses between, and a crane runway carried by the columns. The novelty of the design in this case lies in the proportions of bent spacing to span and height and in the construction of the crane columns used in the house.

FIG. 3. CONDUITS IN FOURTH FLOOR OF SWITCH HOUSE, BEFORE CONCRETING

The traveling crane of the turbine house has a capacity of 100 tons (on two hooks—that is, the crane is a two-trolley crane, with each trolley of 50 tons' capacity and a 10-ton auxiliary hoist) and spans 87 ft. 9 in. between rails. The height of the building is 66 ft. to the crane rail and 75 ft. 6 in. to the bottom of the roof truss. With these proportions the column or bent spacing of 22 ft. is remarkably short. This is accounted for in part by the fact that the roof construction is heavy, due to the reinforced-concrete roof slab, and by the crane capacity and the entire weight of the crane girders, as well as loading from the main floor.

The crane-column construction is of a remarkably substantial nature. A sectional sketch in Fig. 2 shows its make-up—two box-column units, each designed to be built up of channels and plates (in actual construction 18-in. I-beams were used instead of 18-in. channels, because channels could not be obtained without delay), combined to form one double-cell section, with the heavier unit forming the crane-girder support.

In designing the crane runway the following loads were taken into account: Weight of crane, 200,000 lb.; load on

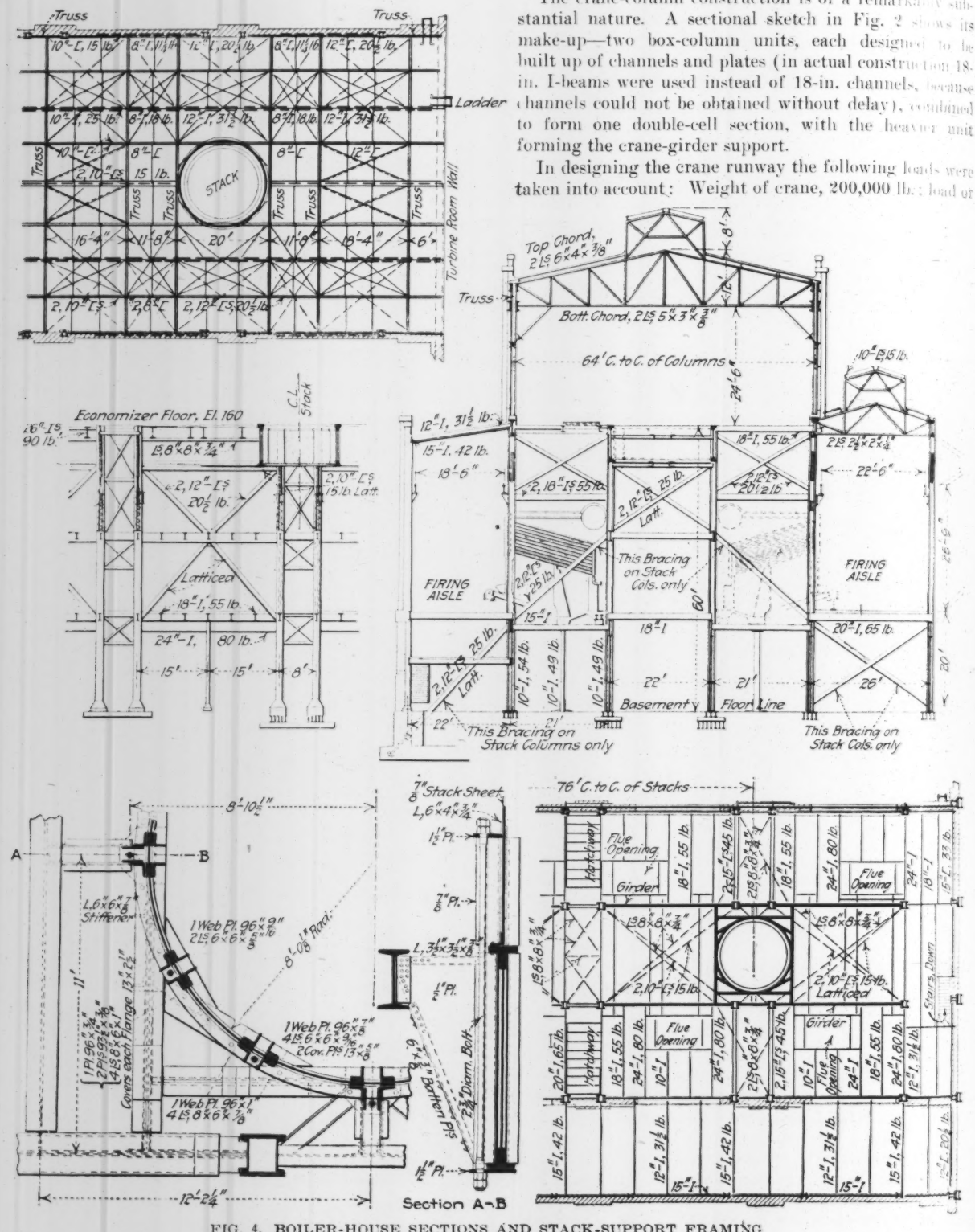


FIG. 4. BOILER-HOUSE SECTIONS AND STACK-SUPPORT FRAMING

capacity of crane, 100 tons; vertical impact amounting to 10% of the crane capacity and horizontal impact amounting to 20% of the crane capacity. Each girder was designed on this basis for a vertical load of 480,000 lb. total (made up of 200,000 net lifted load, 100,000 lb. representing half the weight of crane structure, 40,000 the weight of the carriages and 140,000 the vertical impact) and 40,000 lb. horizontal load due to impact of traveling carriages fully loaded.

It happened that the traveling crane of the turbine house was needed long before the house itself. The generator stators, on account of their size, had to be shipped in two parts, and therefore had to be built up with the core laminations and windings after arrival on the ground. This required the service of a crane of heavy load capacity. It was decided to use the regular traveling crane of the turbine house. Therefore one panel of the turbine house, with its crane girders, was erected, and the traveling crane set in place. A 100-ft. gin-pole did this steel erection. Then two wooden shacks were built in the panel (see view, Fig. 1), as housing within which the assembly (left) and winding (right) went on. Removable roof sections provided for lifting the stator castings and material in and out.

The view, Fig. 1, shows the turbine house shortly after erection of the remaining steelwork was started. The crane, however, is shown in the same position it occupied when only the braced end panel of the frame was up.

The steam turbines are carried on steel framework independent of the framing of the house. This consists of a column-and-girder platform designed to accommodate the condensers under the turbines, on lines similar in a general way to those described in our issue of Jan. 14, 1915, page 66. These turbine-foundation columns are set on piers and walls built on the foundation mat. The steelwork of the platform between the outside girders was filled with concrete to insure rigidity of the joints. The box columns are filled with a concrete grout poured in from the top, 2-in. holes being left for this purpose in the channels of the columns. The space between the columns and kneebraces is likewise filled with concrete to give rigidity to the joints.

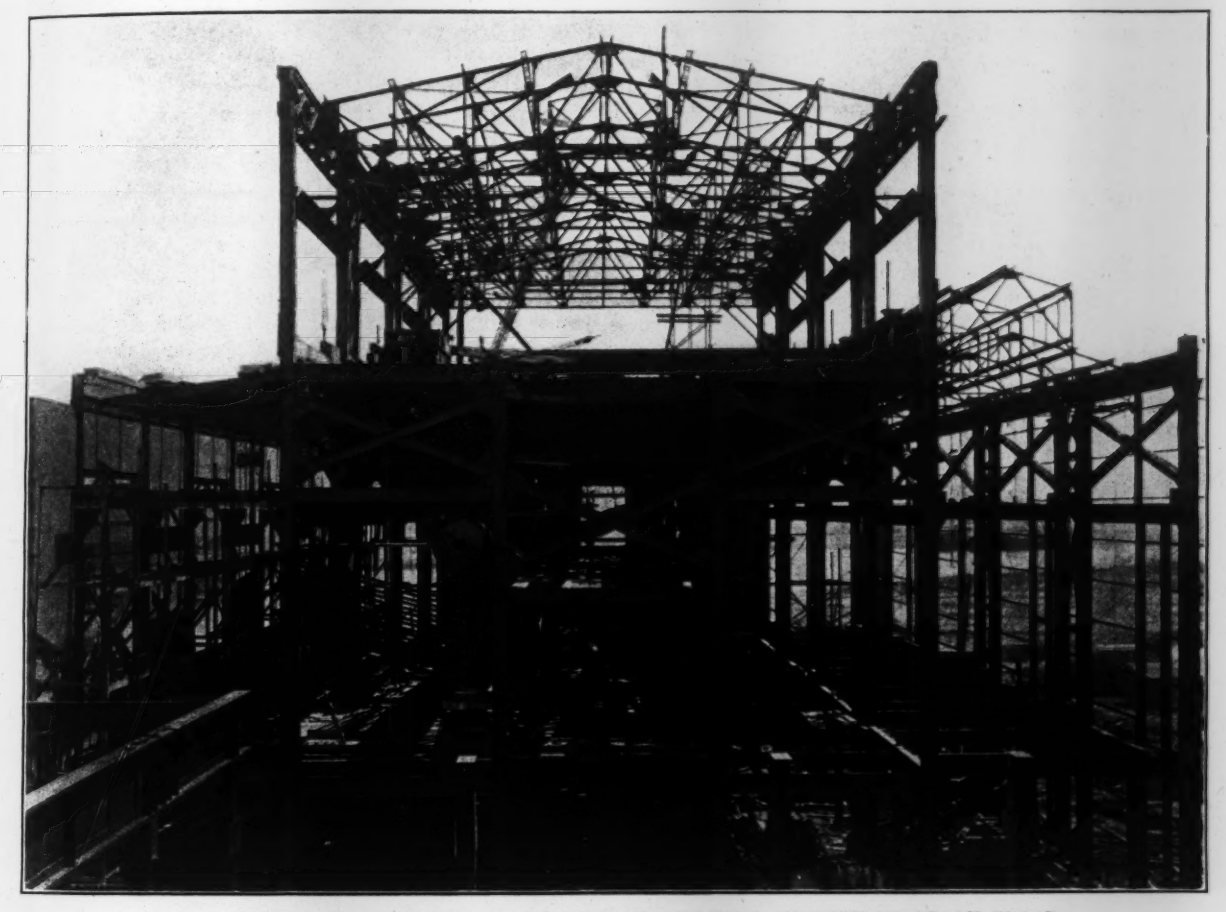


FIG. 5. WEST END OF BOILER HOUSE, VIEWED AT LEVEL JUST BELOW STACK FLOOR
Note diagonal bracing transverse to building to resist the wind pressure on the stacks

The width of the turbine house is more than ample for the 25,000-kw. turbines, of which two have been installed at present. The third unit, which the present section of the turbine house has been designed to accommodate, may be of larger size. The designers figure, however, that the turbine room is of ample width to accommodate the largest steam turbine likely to be built in the future. For this reason, although the turbine house accommodates three units, the foundation framing has been designed and built for only two of them. The support for the third would depend in proportions and strength on the turbine to be subsequently adopted here.

The general arrangement of the boiler house is represented fairly well by the cross-section in Fig. 4 (see also view, Fig. 5). The extension of the house is to be by the addition of successive boiler and firing aisles which will be duplications of the present structure.

Special features of the framing are: (1) The arrangement of the transverse bracing, (2) the use of auxiliary columns under the bridge, front and rear walls of the boiler furnaces to reduce the weight of metal in the girders otherwise necessary and (3) the arrangement of the roof framing on the economizer floor.

The attic story, or economizer room, of the building will receive the economizers, and clear space had to be provided between the roof trusses sufficient to pull out economizer tubes. By this requirement, in conjunction with the location of the two steel stacks, the spacing of the roof trusses and diagonal bracing was determined. The locations thus fixed did not coincide with the column locations, and the roof trusses are therefore carried on longitudinal eave girders of truss construction, running along either side of the building. However, it was desired to secure the same lateral stiffness that would have been obtained with roof trusses framed directly into the columns and provided with kneebraces. To this end each roof truss is fitted with a deep kneebrace at either end, and a plate girder in the plane of the kneebraces on other side of the building transfers the reactions to the columns, thus making this structure rigid against wind.

The necessity of leaving clearance for the economizer tubes also made it impossible to put in the usual lower-chord lateral bracing. The matter of bracing was therefore worked out by using lower-chord laterals inward from the eaves to the first main panel point, thence carrying a diagonal system back and up to the top chord in the plane of a truss diagonal and continuing across the middle of the roof span in the plane of the top chord.

Longitudinal bracing of the building is provided in the bays adjacent to the stack by full diagonals in all the lines of columns transferring the reactions over as large a base as possible. This bracing is clearly shown in Fig. 4.

Brick-Lined Stacks 270 Ft. High

The two steel stacks are supported at the level of the economizer floor, each by a system of 96-in. plate girders arranged in a square. The columns are stiffened by planes of bracing in both directions. On account of the large wind reaction from the stacks, the lateral stresses from this girder group are distributed through the entire floor by a system of floor diagonals to prevent any possibility of twisting the structure.

Each stack-base ring is held down to the main girders by twelve 2¾-in. anchor bolts (upset to 3¼ in.) extending down to the bottom flange of the girder. It was not thought safe to depend on these anchor bolts or on friction for taking the wind shear, and on this account the base ring is connected to the girder flange by twenty-four 1¼-in. turned bolts fitted into holes reamed through base ring and girder flanges to take the entire shear due to pushing the stack off its base by the force of the wind.

The stack, 16 ft. in diameter by 213 ft. 5 in. high above base ring, which is 60 ft. above the basement floor, consists of simple plating with a sectional firebrick lining. The top of the stack is capped with a sectional cast-iron ring. The lining is supported on shelves and provided with holding plates. Under each of the four-column stack groups the concrete mat of the foundation had to be made 5 ft. thick in order to distribute the load over the required number of piles. However, in spite of great stack load it was not thought necessary to reinforce the mat with steel. The stacks were designed for two-thirds of 50 lb. per sq.ft. diametral projection.

Plant Designed Without Outside Retainer

The general design of the Essex station was carried out by the engineering department of the Public Service Electric Co., headed by N. A. Carle, Chief Engineer. The steel design was largely handled by R. Von Fabrice, Chief Draftsman. The Lackwanna Bridge Co., Buffalo, N. Y., is furnishing and erecting the general steelwork. The turbine platforms, however, were let separately to the Pennsylvania Steel Co., for whom Alfred E. Norton is erecting the steel.

A remarkable fact is that throughout the entire planning and building of the Essex station no engineering or architectural assistance outside of the regular organization of the Public Service Electric Co. was employed. The difficult foundation conditions, the complex steel structure and the elaborate mechanical and electrical plant were planned out by the company's engineers after a study of all the recent large power stations in the country and utilization of the best ideas found there, together with the ideas developed by the designers themselves. As a result it is expected that a very low generating cost will be realized in addition to the low construction cost. Remarkably good architectural effects have also been secured, notably in the exterior of the switch house, where the material is common brick.

Steel-Reinforced Asphalt Roof

Reinforced-asphalt roofing will be put on a high-service reservoir to be built by Boston on Bellevue Hill. The reservoir is a steel tank 100 ft. in diameter by 44 ft. high, inclosed within a stone and concrete tower 108 ft. 2 in. inside diameter. The masonry shell is roofed over by concrete carried by a steel-beam framing supported on columns, and this concrete is to be covered by 1 in. of asphalt mastic, reinforced with wire mesh according to the following specifications:

The Neuchatel (Val de Travers) rock asphalt-mastic blocks shall be brought to the site of the work with the name of the above trade-mark stamped thereon. The mineral matter used shall be clean, sharp sand, good sharp grit, fine beach gravel or granite screenings, free from dirt and loam. The reinforcing material shall be No. 16 galvanized-wire fabric, 2-in. mesh. No artificial mastic or coal-tar products shall be used in the preparation of the materials or while laying and finishing the work.

The materials shall be mixed in the following proportions: Rock asphalt mastic, 50 to 55 parts by weight; asphalt fluxes, 10 to 12 parts by weight; mineral matter of stone, grit or granite screenings, 35 to 38 parts by weight. The asphalt blocks shall be broken and melted in regular asphalt-mastic kettles, together with the necessary asphalt fluxes, after which the mineral matter of sand, grit, beach gravel or granite screenings shall be added and thoroughly incorporated by stirring, and the whole mass shall be heated to the temperature of 250° to 300° F.

After sufficient cooking and stirring, the asphalt shall be carefully and uniformly spread in place over the foundation to a depth of ½ in. with wooden spatulas or floats and thoroughly worked or rolled until it is free from voids and an even surface is obtained. The asphalt mastic shall be laid in two layers each ½ in. in thickness with the galvanized-wire fabric embedded in the lower layer. The final surface of the asphalt mastic shall be dusted with either portland cement or white sand, and when laid it shall be perfectly water-tight.

Coleman du Pont Concrete Road

SYNOPSIS—A 20-mi. section nearing completion in Delaware. Extensive experiments with hydrated lime. Different kinds of reinforcement and methods of construction. Expansion joints placed when work is suspended for more than 15 min., and at irregular intervals to determine results. Power screed used on one section.

The first section of the Coleman du Pont Road in Delaware is being completed between Selbyville on the Delaware-Maryland line and Georgetown, Sussex County. This highway, generally of reinforced concrete, is financed by Gen. T. Coleman du Pont for the benefit of his state. The first section will cost more than $200,000 exclusive of the expense of securing a 200-ft. right-of-way. The entire project, 100 mi. long, running the length of the state, is estimated to cost $3,000,000. The present construction is divided into four contract sections, numbering from Selbyville north. A typical cross-section of the road is shown in Fig. 2. The maximum degree of curvature is 2°, and the limiting grade in Sussex County is 2%.

FIG. 1. BOXES USED TO ACCURATELY MEASURE CONCRETE MATERIAL BEFORE ENTERING MIXER

The general surface in Sussex County is mostly sand or clay or a mixture of these. When the roadbed is in drifting sand a small amount of clay is added to facilitate compacting the subgrade. The side slopes vary from 1½:1 in the firmer earth to 2:1 in the sandy soil and 4:1 on embankments where no guard rail is provided.

Embankments are built up in 8-in. layers, and each layer is rolled for its entire width. When possible, material for fill is secured within the slope lines, 20 ft. on each side of the center line. When this material is unsatisfactory for embankments, subgrade or shoulders, earth is obtained from borrow pits. If any black soil, sod or vegetable matter is encountered, it is removed before preparing the subgrade. In one instance, however, where the road traversed a swamp, it was decided that if the specifications were followed the cost would be excessive. The roots and brush that constituted the surface of the swamp floated on soft muck. Holes were cut in the surface of the swamp near the toe of the fill, and the muck was forced out through these holes by the weight of the fill; thus the fill was allowed to settle to firm foundation. This method saved about $1,500.

Drainage everywhere is very carefully planned. The average grade is only 1 ft. in 2,000, while in the most difficult section (from the standpoint of securing adequate drainage) the fall is 1 ft. in $\frac{3}{4}$ mi. Drainage maps were made showing the drainage survey to extend about ½ mi. on each side of the highway. Without these surveys it would have been impossible to secure a good drainage system.

The Concrete Wearing Surface

The concrete pavement is 11 ft. 7 in. deep in the center and 5 in. at the side. On each side of the concrete there is a 4-ft. shoulder of earth, making the available roadway 22 ft. wide. The pavement is reinforced throughout, with the exception of places where it was decided to leave it out for the sake of experiment. Expanded metal was used for reinforcement, although other kinds of reinforcement were tried. It is placed 2 in. from the top surface in all but a few cases.

Great stress was laid on the accuracy of measuring the concrete ingredients. Wooden measuring boxes of 2-cu.ft. capacity were used by all contractors, and this

method was held in great favor by all parties. The scheme is explained in some detail in *Engineering News* of Oct. 21, 1915, and is illustrated in Fig. 1. While it was very simple to measure the same amount of stone, sand and

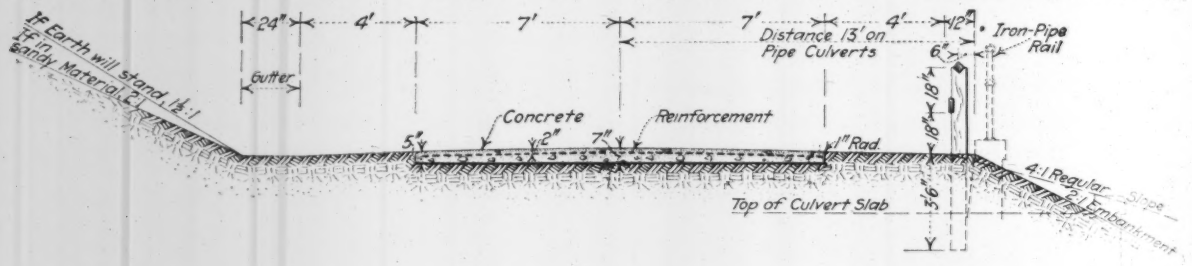


FIG. 2. TYPICAL CROSS-SECTION OF COLEMAN DU PONT ROAD

cement in each batch, it was not such a simple matter to keep the batches of the same consistency. This was in part due to the variation in the amount of water that could be introduced into the drums of the concrete mixers when the water regulators were kept in the same position. A device to obtain exactly the same amount of water in each batch of concrete has been made, and it is hoped it can be attached to all the mixers on the du Pont Road before construction starts in the spring. It will do away with the variation of the consistency of the batches and thus give a more uniform concrete.

The specification for concrete mix is as follows:

The proportions of ingredients shall be approximately 1 bag of portland cement, 2 cu.ft. of fine aggregate and $\frac{1}{10}$ cu.ft. of hydrate of lime. This may be varied slightly in order to obtain the densest mixture, if so approved by engineer.

Acting under this clause the engineer took occasion to vary the proportion of hydrate from zero to 10% of the cement content, with a view to observing the effect of varying quantities of hydrate on both the deposition of the concrete and its wear in a road surface. The experiment is not yet sufficiently advanced to warrant conclusive deductions.

Each batch of concrete consisted of 2 bags of cement, 4 cu.ft. of sand, 8 cu.ft. of stone and hydrate as stated. The time of mixing was 1½ min., at a minimum of 15 r.p.m. Before the concrete was deposited, the surface of the subgrade was sprinkled with water. There were seven concrete mixers in service in October, 1915. Each mixer averaged 300 lin.ft. of pavement per day.

After carefully considering many coarse aggregates that were available, it was decided to use traprock. This was obtained from quarries in the state and transported as near to the line of the road as possible. Narrow-gage construction railways conveyed the stone from the rail-

FIG. 3. SEVERAL ELEMENTS IN THE CONSTRUCTION OF THE COLEMAN DU PONT ROAD IN DELAWARE

Foreground—Imbedding the reinforcement. Center—Floating the finished concrete. Rear—Canvas-covered frames protecting fresh concrete from sun. Boom of mixer extends in foreground

way to the job, where it was dumped on the subgrade. The requirements of the traprock were that it should have a French coefficient of wear of at least 17, and should be the run of the crusher that would pass a 1½-in. ring and be retained on a ¼-in. screen. The sand used was dredged sand of exceptionally good grading, with the larger particles nearly ¼ in. in size. By using this sand with the graded stone the theoretical grading of the aggregates of the concrete was nearly perfect, and a very dense concrete resulted. A representative of the Bureau of Standards, who made a number of tests to determine the movement of the pavement, declared that the density of this concrete was greater than any he had previously drilled.

In view of the well-known diversity of opinion as regards the spacing of expansion joints, it was decided to place them on this road only when the mixer was shut down for 15 min. or longer. This resulted in some long slabs—in some cases reaching as great a length as 460 ft.

The specifications permitted the use of "any machine devised to finish pavement." On Section 1 a power screed, manufactured by the R. D. Baker Co., was employed successfully. On the other sections hand screeds made by bending 4x4x½-in. angle iron are used.

As soon as the concrete is finished, it is protected from the sun and wind by canvas-covered frames. As soon as possible after the concrete becomes hardened it is covered with 2 in. of earth and kept wet for 14 days. No traffic is allowed on the concrete pavement for at least 30 days.

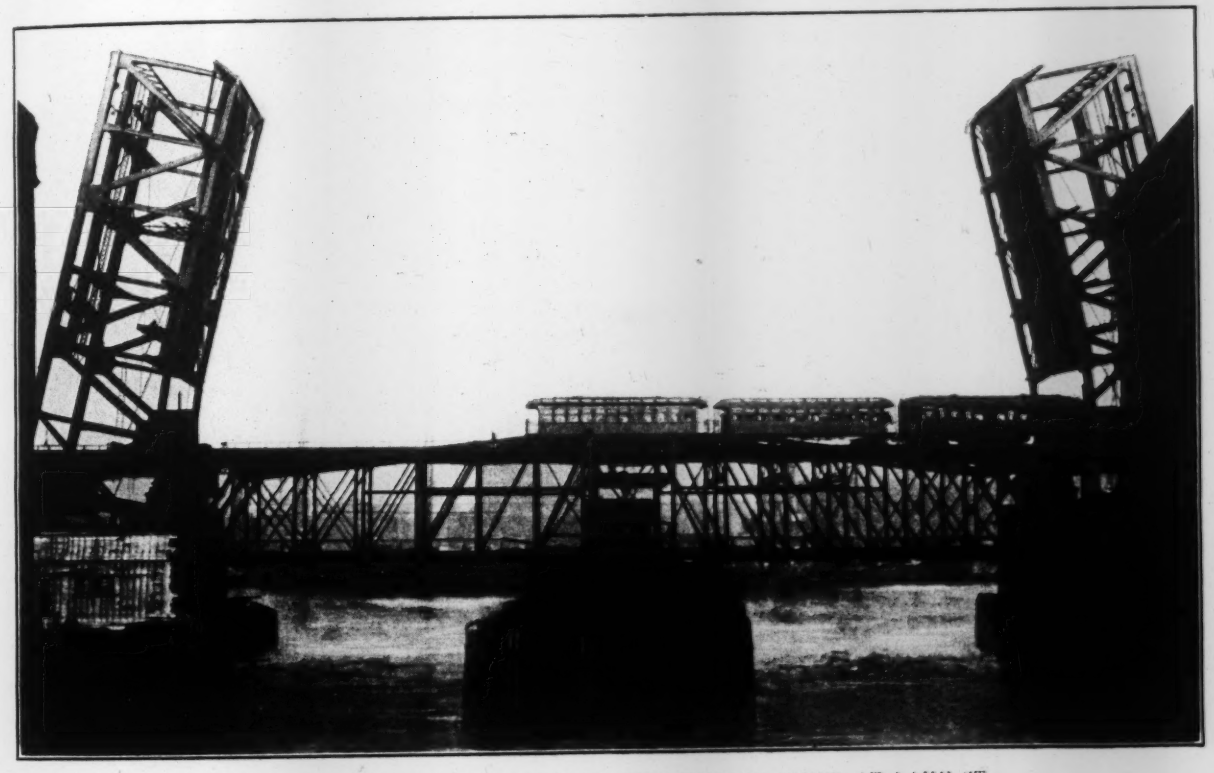
Each of the four contract sections is inspected by a resident engineer, who reports to the Chief Engineer, Charles Upham. Associated with Mr. Upham is C. D. Buck, Superintendent of Construction.

Renewing a Drawbridge Across the Chicago River

The new double-deck bascule bridge and the old center-pier double-deck swingbridge over the Chicago River at Lake St. are shown in the accompanying view, which represents the condition of work a month ago.

The old swingbridge is kept in service to carry the elevated-railway trains, but the roadway is closed to traffic. The bascule bridge was erected with its leaves in the raised position, the deck and bracing of one panel in each leaf being omitted to allow trains to pass through until the bridge is ready for operation. Then traffic will be stopped for a short time while the old bridge is removed and the floor system of the new structure is completed.

The bridge is of the trunnion bascule type, with a span of 245 ft. c. to c. of trunnions, giving a width of 209 ft. between the piers for a channel 195 ft. wide in the clear. The old bridge gives two channels only 65 ft. wide. The trusses are spaced 42 ft. c. to c. and are 30 ft. deep at the center. On the lower deck are a 38-ft. roadway (with car tracks) and two outside 16-ft. walks; on the upper deck is a double-track railway between the trusses.



OLD AND NEW DRAWBRIDGES OVER THE CHICAGO RIVER AT LAKE ST.

The bridge was designed and built under the direction of John Ericson, City Engineer, and Thomas G. Pihlfeldt, Engineer of Bridges and Harbor. The contractors were the Fitzsimons & Connell Dredge and Dock Co. for the substructure, the American Bridge Co. for the steelwork, and the Ketler-Elliott Erection Co. for the erection. The steel was stored on the dock shown beyond the center pier and was floated into place on lighters.

The bridge and its construction were described fully in *Engineering News*, Nov. 4 and 11, 1915.

A 2,223-Ft. Concrete-Arch Bridge Built on Reverse Curve

By A. M. Richter*

SYNOPSIS—A long bridge, curved in plan, with arches of two types; 211-ft. spans, with three arch ribs carrying crosswalls, and 134-ft. spans, with barrel arches. All are reinforced by steel truss ribs. Concrete was placed by a cableway of 2,038-ft. span, handling drop-bottom buckets. The entire construction is being done by the city on the day-labor system.

The construction of the Third Ave. reinforced-concrete arch bridge across the Mississippi River at Minneapolis, Minn., has involved unusual engineering difficulties and presents features of interest in both design and construction. The bridge is notable for its size, because it is curved in plan and because it is being built on the day-labor system, which has been employed for some time in the city engineering department. Some stages of the work under construction are shown in Fig. 1, and the general plan is shown in Fig. 2.

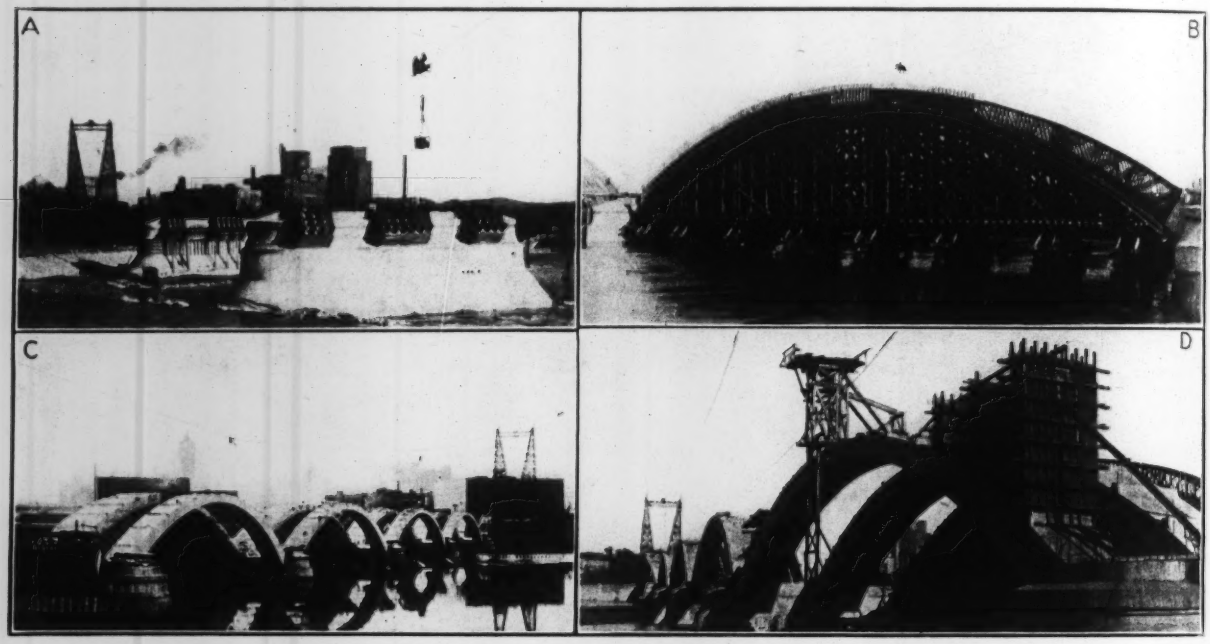


FIG. 1. CONSTRUCTION OF REINFORCED-CONCRETE ARCH BRIDGE OVER MISSISSIPPI RIVER AT THIRD AVE., MINNEAPOLIS, MINN.

A—Piers 4 and 5, showing ends of steel arch ribs, and tail tower of the cableway (Nov. 20, 1914). B—Falsework and steel reinforcing ribs for first 211-ft. arch (July 2, 1915). C—Arch ribs of the five 211-ft. spans; the third line of ribs (at the left) not built (Oct. 12, 1915). D—Fifth 211-ft. span, with two ribs completed and falsework and steel reinforcement in place for third rib. On the outer rib are forms for the cross walls, and a tower for the concreting chute

Troublesome Geological Conditions

Of special interest are the geological conditions which affect the foundation work and which account for the curved line of the bridge. The geological formation of the river bottom at the bridge site consists of a limestone bed about 15 ft. thick, which is practically bare in the west channel and covered only by a few feet of silt and sand in the east channel. The limestone ledge rests on the St. Peter sandstone, which is about 600 ft. in depth. This sandstone is readily excavated with picks and is easily eroded by the action of water, especially when under a head. The limestone extends upstream about 500 ft. from the bridge and downstream about 700 ft. to the crest of St. Anthony Falls.

In the early construction of works to utilize the power from St. Anthony Falls a peculiar advantage was afforded by the facility with which tunnels could be excavated in the soft sandstone. The water was led from the mill pond in a canal above the limestone, and the tunnels served as tailraces. In 1869, however, one of these tunnels had reached a point near the foot of Nicollet Island (2,000 ft. from the point of beginning), when water poured in from a break in the overlying bed of limestone. The project had to be abandoned, and the United States Government made extensive repairs to close the break in order to insure continuance of the water-power and restore the original conditions as far as possible. Another break occurred in 1876. The locations of these breaks in the river bed and their relation to the bridge projects are shown on the plan.

With the growth of the city, there has been strong demand for a bridge in the neighborhood of Third Ave. South. It was desired that this should be of handsome appearance, and a concrete arch structure was considered

*"Minneapolis Journal," Minneapolis, Minn.

the best to meet the requirements of the situation. In 1912 the City Council commissioned the Concrete-Steel Engineering Co., of New York, to prepare designs for a reinforced-concrete arch bridge between Third Ave. South and First Ave. Southeast. The location is indicated by a dotted line on the plan.

The design was subjected to a public hearing before the engineers of the United States War Department in 1913. The water-power companies had not favored any bridge project and announced that, if necessary, they would resort to litigation to oppose any work threatening danger to the falls.

Shortly after affairs had reached this stage, Frederick W. Cappelen was elected city engineer. While bridge engineer for the city in previous years he had built six bridges across the Mississippi River and acquired a thorough knowledge of river conditions. He refused to approve the proposed location. The City Council then rejected the plans and instructed him to design a steel bridge that could be constructed without endangering the falls or affecting water-power rights.

His proposed location is shown on the plan, and his design included one span of 134 ft. to clear entirely the area of the limestone breaks. The trusses were to be of the parabolic through-truss type. In the face of objections (based mainly on æsthetic considerations) the City Council approved the plans and directed the engineer to proceed with construction.

At this time, however, Mr. Cappelen conceived the idea that by adopting a curved location for the line of the bridge, a design satisfactory to all parties might be worked out. On investigation it was found that at one point the limestone break could be cleared by a concrete arch of 211-ft. clear span. A revised

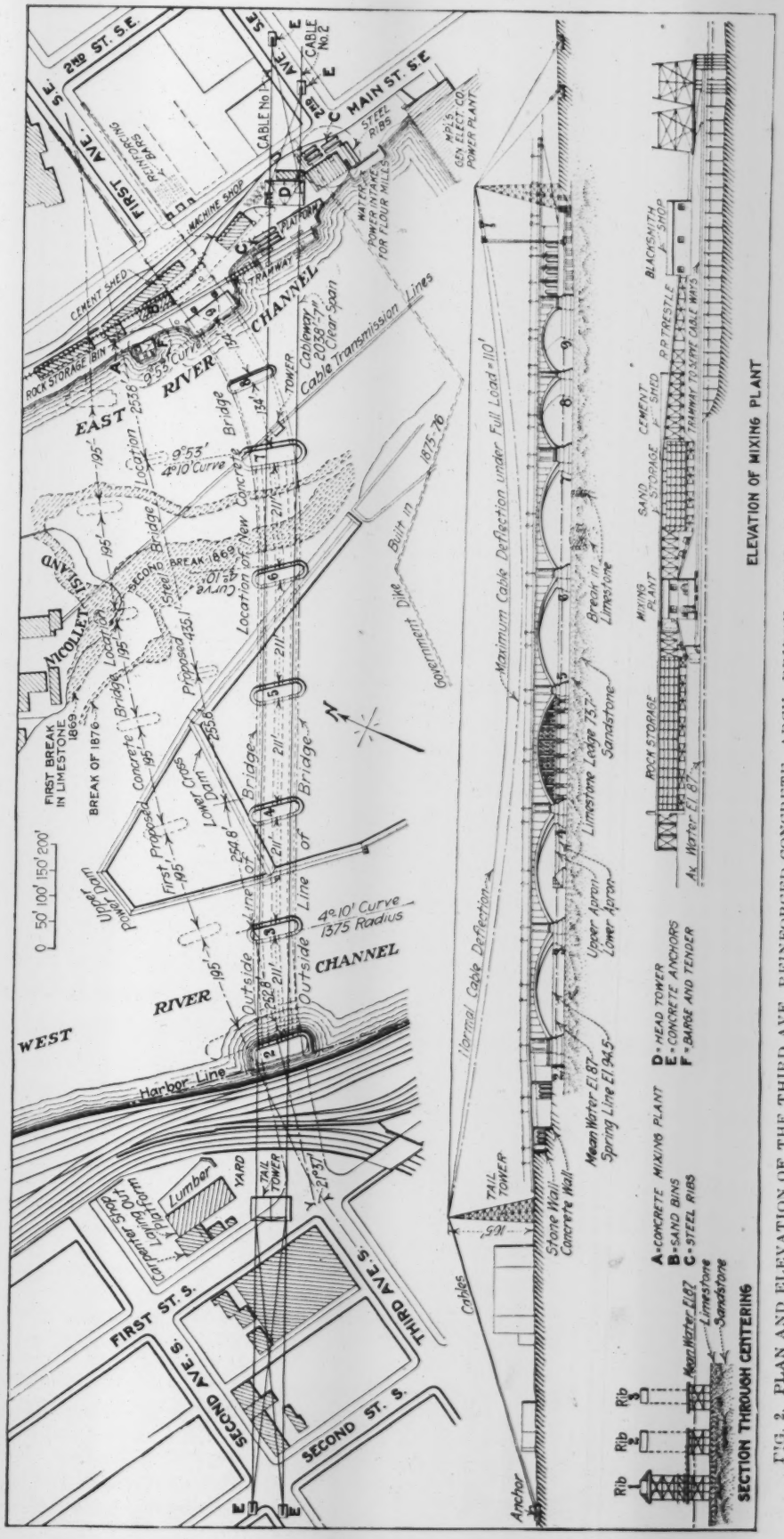


FIG. 2. PLAN AND ELEVATION OF THE THIRD AVE. REINFORCED-CONCRETE ARCH BRIDGE OVER THE MISSISSIPPI RIVER AT MINNEAPOLIS, MINN.

plan for the desired ornamental structure was then prepared. This proved satisfactory to all parties and was finally adopted.

The bridge is 2,223 ft. long and consists of seven main river spans. It has a 54-ft. roadway (with double-track street railway) and two 12-ft. sidewalks. The loading provides for two 40-ton cars and 100 lb. per sq.ft. uniform load. The floor system is designed to carry a 24-ton road roller on a space of 12x18½ ft. The center line starts at the intersection of Third Ave. South and First St. at an angle of 21° 39', and is on a tangent for 151 ft. to a 4° curve 330.2 ft. long. A tangent 719 ft. long continues to a curve consisting of a 4° compounded into a 10° curve in a distance of 526.83 ft., bringing the center line of the bridge to that of First Ave. Southeast. The bridge is level, with a grade of 0.9% on the east approach and 3.4% on the west approach.

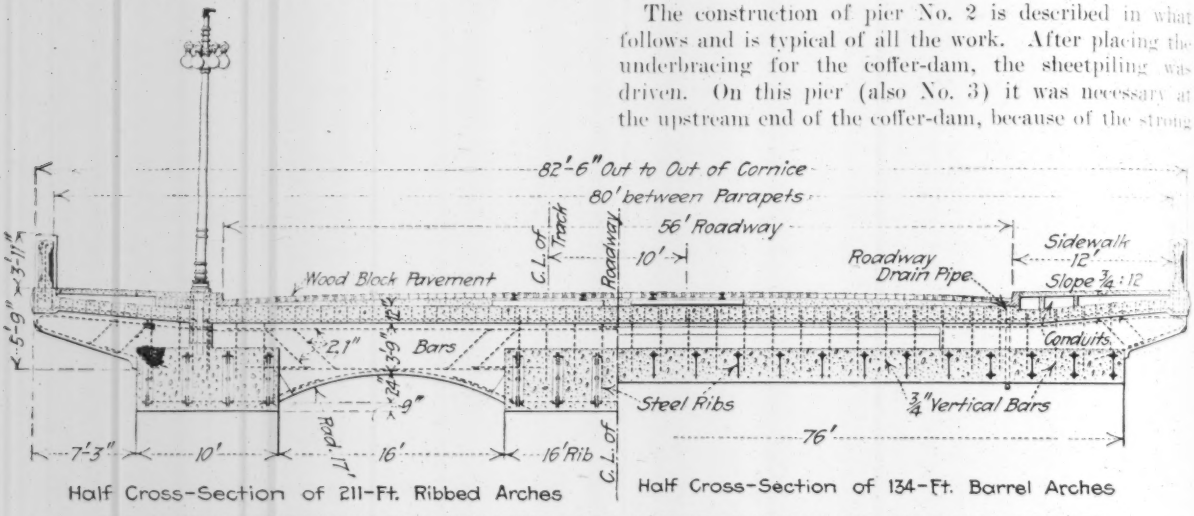


FIG. 3. CROSS-SECTION OF THE CONCRETE ARCH BRIDGE AT THIRD AVE., MINNEAPOLIS, MINN.

There are five 211-ft. spans with piers 20 ft. wide at springing line and two 134-ft. spans with an intermediate pier 13.79 ft. wide. The two end, or abutment, piers and the pier between the 211-ft. and 134-ft. spans are 30 ft. wide. The approaches are steel girder spans on thin piers. All the river piers are skew to the center line. The 211-ft. spans are on the tangent of the 4° curves and the 134-ft. spans are on the 10° curves.

Each of the 211-ft. spans is carried by three arched ribs of 36-ft. rise, as shown in the cross-section, Fig. 3. The outside ribs are 12 ft. wide in the two end spans and 10 ft. in the intermediate spans, while all center ribs are 16 ft. wide. The reinforcing is of the Melan type, consisting of ribs of 4x4x½-in. angles laced with 3x3x$\frac{5}{16}$-in. angles (at haunches) and 2½x⅜-in. bars. There are six of these ribs in each 16-ft. arch rib, five in the 12-ft. and four in the 10-ft. ribs. They are braced every 30 ft. with 3x3x$\frac{5}{16}$-in. angles.

The two 134-ft. spans over the east channel are full-barrel arches (Fig. 3) with Melan ribs of 3x3x$\frac{5}{16}$-in. angles laced with 2½x¼-in. bars. These are spaced 34 in. c. to c. and cross-braced every 30 ft. with 3x3x⅜-in. angles.

Carrying the floor system from the ribs are transverse walls and girders supporting the floor slab and brackets supporting the sidewalk slabs and parapet-wall beam. These are shown in Figs. 3 and 4.

The piers were constructed in open coffer-dams of Lackawanna steel sheeting, some of the sheeting being used three and four times. The coffer-dam dimensions were as follows: Pier No. 2, 46x121 ft.; Nos. 5 to 6, inclusive, 37x113 ft.; No. 8, 24x101.5 ft.; No. 7 (between the larger and smaller arches), 46x131 ft.; east abutment pier, 42x110 ft.

Practically no silt was found on top of the ledge at piers Nos. 2, 4 and 5, but there were from 6 to 12 in. at No. 3, 5 ft. at the downstream and 7 ft. at the upstream ends of No. 6, 9 and 10 ft. at No. 7, 8 ft. originally and scouring out to 3 ft. minimum at No. 8 and 8 ft. at pier No. 9. The depth of water was 16 ft. at piers Nos. 7, 8 and 9, 12 ft. at Nos. 2, 3, 6 and 12 and 5 ft. at Nos. 4 and 5.

The construction of pier No. 2 is described in what follows and is typical of all the work. After placing the underbracing for the coffer-dam, the sheetpiling was driven. On this pier (also No. 3) it was necessary at the upstream end of the coffer-dam, because of the strong current, to anchor 15-in. I-beam sills to the rock bottom with 2-in. rods to hold the lower end of the sheeting in place. This is shown in Fig. 5.

The steel sheeting was very tight and was made entirely water-tight by a filling of coal dust and fine cinders. Sandbags were placed around the bottom of the sheeting and then pumping was started. If water came in through fissures in the rock, pumping was stopped and the bottom course of concrete, 5 to 6 ft. thick, was placed under water. After this had set, the coffer-dam was pumped out and the remainder of the work placed dry. This was done on piers Nos. 2, 6 and 8 and partly on No. 3. Excavating for piers Nos. 6 and 8 was done entirely with orange-peel buckets. The rock in these coffer-dams was cleaned by divers with water jets. The other foundations were placed dry, but always in sections, and generally four sections to each coffer-dam.

The silt on top of the bedrock was full of old water-soaked logs that caused trouble in the excavation. Two slight breaks occurred in coffer-dam No. 3. Both occurred during night shifts, and might have been prevented had there been an intimation of a break during the day.

Construction of the Piers

After the footings were completed, the piers were concreted in forms which were used over and over again (Fig. 6). The first section above the footing was carried above water level, generally leaving a center space considerably below water level to receive the ends of the

steel ribs. Finally this part of the pier containing the ribs was cast in one continuous pouring. This amounted to about 1,000 yd. on piers Nos. 3, 4, 5 and 6, 1,266 yd. on Nos. 7 and 9 and 750 yd. on pier No. 8. The record run was 1,000 yd. in 22 hr.

Pier construction was carried on through the winter except when the temperature was below zero, special precautions being taken against freezing. The forms were entirely inclosed with tarpaulins (Fig. 6) and heated with coke stoves. The sand and rock bins were supplied with heaters, and when necessary the cableway buckets for handling concrete were dipped in hot-water tanks on shore. Careful records were kept of temperatures of materials at deposit points. As a result, there was no trouble from frozen concrete.

Concrete deposited under water was a 1:2:4 mixture. All other concrete in the piers was 1:3:6. It was mixed in batches of about 1 yd. (24 ft. of stone, 12 of sand and 4 sacks of cement), two batches to each bucket. The stone was mostly traprock from Dresser Junction, Wis., crushed to a maximum size of 3½ in. The sand was a Minnesota product. A timber tower about 50 ft. high, with crib bottom for anchorage, was placed adjacent to the pier, standing on the river bottom. The tower had a hopper near the top, with a chute to the forms. The cableway buckets delivered concrete to the hopper, where a man regulated the discharge to the chute. The towers were picked up bodily by the cableway and moved from place to place.

The first coffer-dam (pier No. 2) was begun Aug. 2, 1914, and the pier work was finished June 28, 1915. The river froze solid early in December, and the ice left the west channel in March and the east channel in April. Between the dates mentioned, 27,000 yd. of concrete was laid in pier construction.

Falsework for the Arch Spans

Falsework for the arches was begun Apr. 19, after the ice was out. One set of falsework was designed for the center ribs for the five 211-ft. spans. It was made in seven sections per span, supported by 24-in. 70-lb. I-

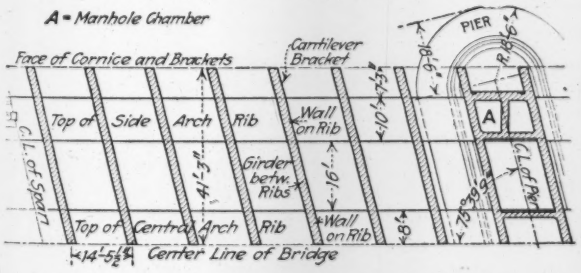


FIG. 4. PART PLAN OF 211-FT. ARCH SPAN
Showing the arch ribs and cross walls

beams, 28 ft. long on the inside sections and 26 ft. on the two end sections. The I-beams were supported on cribs made of eight 10x10-in. posts braced and capped and having open plank bottoms for loading with sandbags to sink them into place. These cribs were placed 28 ft. 11 in. c. to c. (Fig. 1).

The falsework to carry the ribs was of 8x8-in. posts braced with 2x10-in. planks. The bents were capped and furnished with wedges under caps supporting the joists which carried the lagging and the framework for the rib. The lagging and side forms were of 1-in. tongued-and-grooved plank, the forms being supported by 4x4-in. posts and 4x6-in. longitudinal timbers.

The I-beams rested on 8-in. blocking, so that when the centering had been used for one rib, the entire falsework could be moved into place for the next rib by replacing the blocking with rollers. This falsework was placed in position for the upstream rib first and cribs were placed also for the center ribs at the same time. Trouble was experienced in placing them because of high water and

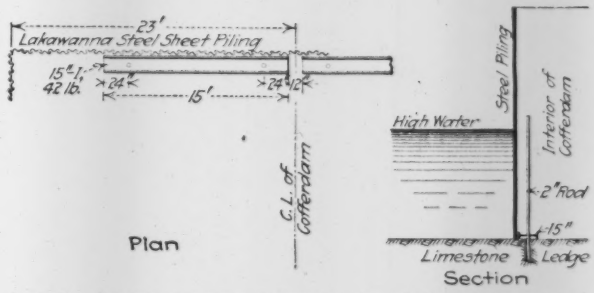


FIG. 5. SUPPORT FOR BOTTOM OF STEEL SHEETING FOR COFFER-DAM

because several cribs were located on the roll dams and aprons. The use of the 24-in. I-beams of 26- and 28-ft. length was decided upon in order to utilize the material for the floor spans of the approaches.

Concreting the Arches of the Bridge

The first arch rib, between piers Nos. 2 and 3, was poured July 8, 1915; 240 yd. of concrete was handled on one cableway in 11 hr. over the center section of the rib. The steel ribs were then riveted at the haunches during the next night and the two end sections poured simultaneously the following day, both cableways being used for 9 hr. to handle 340 yd. of concrete. The last upstream rib was poured Aug. 5. Two days later the centering was struck under the first rib and the falsework rolled over by means of a crab on pier No. 2, with block and tackle hitched to each section. The whole centering for one span was thus moved in one day.

On Aug. 16 the centering for the next span was moved into position and on Aug. 19 and 21 the center rib was poured—768 yd. in 24 hr. A record run was made on the center rib finished Aug. 28, when 450 yd. was poured in 7½ hr. with both cableways, or one bucket every 2 min., at a distance of 1,600 ft. from the mixers. The concrete for the ribs is a 1:2:4 mix, using ¼- to 1½-in. stone.

The program for the rest of the work provided for pouring one rib a week until all 15 were completed. The cribs for the upstream ribs were moved and used again for the third ribs on the downstream side. The centering for the last rib was moved over into place in 2 hr. 40 min.

In October, 1915, the timber for the first three 211-ft. spans was moved over to the 134-ft. spans in order to finish the arches before cold weather sets in. The transverse walls are being put in, and only the floor proper will remain to be put in next spring. It is expected that the new bridge will be opened to travel not later than June 1, 1916.

The alignment of the bridge and skew of the piers necessitated an elaborate system of location. The triangulation had for its base the center tangent line of the bridge.

A series of large triangles was laid out on either side of this base line, regard being given to prominent points as targets for the apices of the triangles.

A secondary triangulation system was calculated, with proper attention to balancing errors for the location of the instrument platforms. Upon this the intersection points of pier, transverse center lines and base line of platforms were accurately established. These intersections were established with ordinary transits reading to 30 sec. Seconds were interpolated on the platforms by means of thread intersections: the minute next greater and that next smaller to the actual triangle calculated to the nearest second were read by the instrument man and recorded on the platform. Actual measurements show a maximum error of $\frac{1}{4}$ in. in 211 ft.

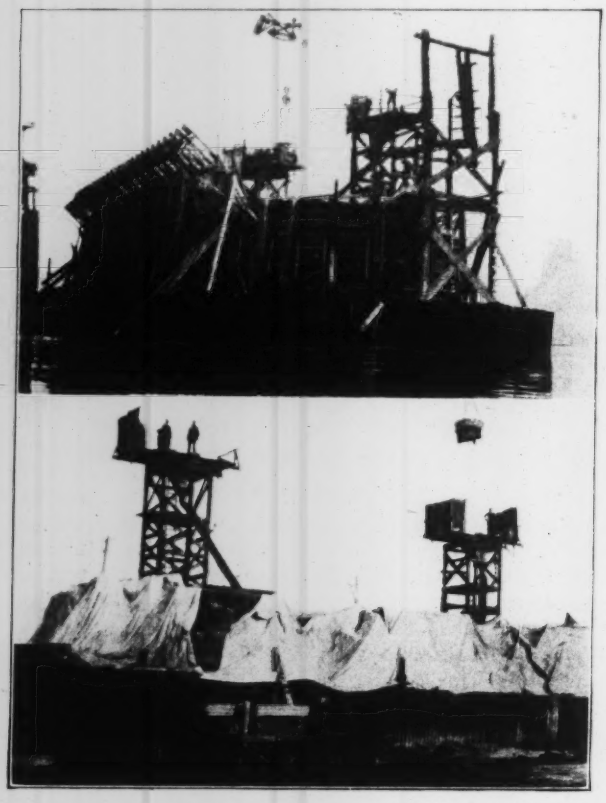


FIG. 6. CONCRETING THE PIERS FOR THE THIRD AVE. BRIDGE

Upper View—Work at pier No. 7 in April, 1915. Lower View—Concreting pier No. 3 during freezing weather in December, 1914

Handling Material by Cableways

The river conditions, as well as railway operations at the site of the bridge, led to the use of a Lidgerwood double cableway to handle the work. This has two 2½-in. steel main cables and is operated by two 75-hp. engines and a 150-hp. tubular boiler. The cables have a working span of 2,020 ft., giving a capacity of 6 tons each at a speed of 1,200 ft. per min. constant work and 10 tons for occasional demand. Fig. 2 shows the location of the cableway and the bridge.

The towers had to be 165 ft. high to insure clearance. The location of the anchors was a difficult problem, which was finally solved by utilizing space in the streets in such a way as to interfere but little with traffic. The towers are 39x76½ ft. at the base. They are built of Douglas-fir timbers, 12x14 to 10x10 in., and capped with oak headblocks, 20x20 in. and 7 ft. long.

The anchors of the head tower (east side) contain 128 cu.yd. of concrete each and weigh 237 tons. They are 22x12½x10 ft. and entirely under the ground. The tail-tower anchors are 22x15x10 ft. each, containing 120 cu.yd. and weighing 230 tons. They are half buried in the street. Each tower is guyed by two 1½-in. lines. Difficulty was met in carrying one of the cable lines over a seven-story building about 100 ft. from the tail tower and in supporting the same line to afford clearance on the street at the anchor, as indicated in Fig. 2. High-water conditions, inability to get near the dam in rowboats and the necessity of precaution against dropping the heavy cable and cutting a power-transmission line, as well as danger of interference with trains on several tracks, were among the complications involved. The task was finally accomplished by using a rope line and then a 1⅛-in. messenger cable to trolley across the 2½-in. cables.

The cableways are located to serve all piers except No. 9, the abutment pier on the east side. This is near the mixing plant and was served direct with towers, elevators and derricks.

The towers were framed on the ground and then erected. The framing began Apr. 1, 1914, and was completed Aug. 1. It was done on the day-labor system, with a crew of 7 ironworkers, 20 carpenters and 15 laborers. The erection cost is estimated at $5,000 and the machinery and special equipment cost approximately $21,000.

Concrete-Mixing and Handling Plant

A difficult part of the work was that of arranging the working plant. There was no room except on Main St. (on the east side), and here some travel had to be provided for. The Great Northern R.R. maintains two industrial tracks on the street and owns the land to the river, which is leased to various concerns. The railway company, however, cancelled the leases and made it possible to establish the mixing plant at that point. Concrete, steel and machinery were located on the east side and lumber on the west side. The layout of the construction plant and supply yards is shown in Fig. 2.

The concrete-mixing plant has a capacity of 400 yd. in 8 hr. There is a 2,000-yd. rock-storage bin 125 ft. long and an 800-yd. sand bin 74 ft. long. The bins are 27½ ft. wide and 12 ft. deep, and are provided with boilers for heating. The material track reaches the top of the bins by a trestle 460 ft. long, with a grade of 4%. Stone and sand are delivered through bottom openings into cars of 24-cu.ft. capacity, which serve the mixing platform by a cable incline operated by hoisting engines. The cement shed, 20x200 ft., of 5,000 bbl. capacity, is served by a sidetrack.

There are two cube-type mixers, each of 1-yd. capacity. They are equipped with steam lines, and in freezing weather the water is run through a reheater. The water tanks are fitted with gages for measuring the supply to each batch. The sand and stone are dumped into the hopper at one level and the cement from a higher level, and the entire charge then spouted into the mixer.

The concrete is discharged into 2-yd. drop-bottom buckets. These are circular in shape, with conical bottoms, and have legs so that they stand upright on flat cars. These cars are hauled between the mixer plant and

the cableway on a double-track cable tramway operated by American reversible hoisting engines.

At the city workhouse prisoners are making the ornamental concrete railing shown in Fig. 7. The concrete is made with mica-spar crystals (from Crown Point, N. Y.) and is cast in steel molds to obtain a smooth finish and polish. The cement workers' union protested against this plan, but finally withdrew its objections. This railing is estimated to cost $20,000.

Other Construction Plant

Space and trackage were very limited on the west side, but three lots at the street level were loaned by the Rock Island Lines. Here was erected a 48x135-ft. platform for framing timber and laying out the centering; also a small planing and ripping mill, tool house, men's house and engineers' field office. The timber is piled high on account of limited space. It is handled by a derrick with a 45-ft. boom and a 47-ft. mast.

The machine shop, 30x60 ft., is also on the east side. It has a blacksmith forge, bolt-threading machine, emery

FIG. 7. CONCRETE RAILING FOR THE THIRD AVE. BRIDGE

grinder, miscellaneous tools and one 4-ton and two 2-ton chain blocks. A track runs under the shop from the cableway tower, so that equipment may be run in for repairs. Two movable derricks in the same location have 65-ft. masts and 50-ft. booms. Completing the east-side layout are the steel storage yards, served by a derrick with 65-ft. mast and 75-ft. boom. Each Melan rib is in its own common pile, some running 35 sections high. The reinforcing steel and bar iron are in separate places bundled and labeled for length and location.

Electric motors are used in the mill and machine shop and for operating the concrete mixers. Electric drills are employed in timber framing. All pumping was done with electric belt-driven centrifugal pumps. Compressed air was used for riveting.

The total cost was estimated at $650,000. The bridge will require 53,000 cu.yd. of concrete, 963 tons of structural steel for the arch ribs, 800 tons of reinforcing bars for piers and 1,500,000 ft. of lumber for centering. The prices for materials delivered at the site were as follows: Crushed traprock, $1.45 per cu.yd.; washed sand, 75c.; cement, $1.20 per bbl.; structural steel (including erection bolts and nuts), $53.50 per ton; reinforcing bars, $1.429 per 100 lb.; Lackawanna 7-in. steel sheetpiling, $1.63¾ per 100 lb.; coal (lump), $4.15 to $4.25 per ton; electric current for light and power, 2.9c. per kw.-hr.

The wages paid by the city (for an 8-hr. day) were as follows: Foremen, $4.50 to $6; ironworkers, $5; carpenters, hoisting enginemen and electricians, $4; handymen, $2.65; laborers, $2.50; water boys, $1.40; teams, $5.

The location was determined and the general design made by Frederick W. Cappelen, City Engineer (with whose aid and approval these notes were prepared). All construction was done under his direct supervision. He also designed the methods of construction, the working plant, falsework, etc. The assistant engineers, all employed in the city engineering department, were as follows: K. Oustad, Bridge Engineer; William Elsberg, Superintendent of Construction; and John E. Lawton, Junior Engineer.

The construction foremen were N. Linstrom, for the forms, concreting and falsework, and J. F. McAuley, for the mechanical equipment. The Concrete-Steel Engineering Co. furnished the detail plans under its original commission of 1912. Its resident engineer on the work was Charles F. Bornefeld.

Large Water-Works Figures

Municipal ownership of water-works prevails in 155 of the 204 cities of the United States having an estimated population of 30,000 or more in 1915, according to a statement just issued by the United States Bureau of the Census. The total estimated value of these municipally owned works is $1,071,000,000. The distribution systems in the 155 cities comprise a total of 36,936 mi. of mains, 330,593 fire hydrants and 1,787,448 meters. The total water consumption in the 155 cities for the year covered by the report was 1,326,028,000,000 gal., supplied to 26,200,000 people, giving an average daily per capita consumption of 139 gal. On the range of water consumption and the effect of meters, the Bureau of the Census says:

> The greatest daily consumption of water per inhabitant, 430 gal., is reported for Tacoma, Wash., and the smallest, 34 gal., for Woonsocket, R. I. In the former city 8% of the water is metered and in the latter 98%. The tendency of meters to curtail greatly the use of water is strikingly shown by a comparison of the figures for the 26 cities in which the entire water-supply is metered with those for the 26 cities in which not more than 25% is metered. In the former group the average daily consumption per inhabitant ranges from 42 gal. in Brockton, Mass., to 179 gal. in Columbia, S. C., and in only 7 cities does it exceed 100 gal. In the latter group it varies from 43 gal. in Savannah, Ga., to 430 gal. in Tacoma, Wash., and in only 3 cities does it fall below 100 gal.

The number of cities with water-purification plants is not given. Instead the statement is made that in the 155 cities of over 30,000 population having municipal ownership there are in operation a total of 87 settling reservoirs, in which are treated 958,600,000 gal. a day; 54 coagulation plants, treating 492,100,000 gal.; 527 sand filters, treating 598,700,000 gal.; and 427 mechanical filters with a daily output of 468,200,000 gal. The surprising total of 1,972,900,000 gal. of water per day is treated by some disinfection process.

The range of cost of water treatment per 1,000,000 gal. is reported as from 4c. per 1,000,000 gal. in Chicago, Ill., for disinfection, to $17.46 in Columbus, Ohio, for "mechanical filtration and chemical sterilization."

More detailed information regarding both municipally owned water-works and various other works and operations of the larger cities of the United States will be published later on under the title "General Statistics of Cities, 1915," compiled under the direction of Starke M. Grogan, Chief Statistician for Statistics of Cities. Sam L. Rogers is Director of the Bureau of the Census.

Field and Office

Sinking a Cylinder Pier by Open Dredging

The south shore pier of the continuous-span channel crossing of the new Chesapeake & Ohio Northern Ry. bridge over the Ohio, at Sciotoville, Ohio, was put down by open dredging through wells—the only foundation on this work put down by other than ordinary methods. The sinking went on quite according to expectations and encountered no difficulties.

The most successful feature of the work was that, although sunk in a sharply sloping bank at the edge of the river, the pier was landed almost precisely in correct position; this is to be credited to the well-judged allowance for downhill shift which was made by the contractor at the start of the sinking.

The Dravo Contracting Co., of Pittsburgh, Penn., did the work under the direction of Gustav Lindenthal, Consulting Engineer, who designed the bridge and foundations.

The south shore pier has a base 70x24 ft., with parallel sides and semicircular ends. Four wells, 7 ft. 3 in. in diameter, spaced 14 ft. 8 in. c. to c., were cored in the concrete for doing the dredging. The lower ends of the wells flare outward sharply for a height of 6 ft.

The pier is located some 30 ft. back from the water's edge, somewhat below the middle of the sloping bank. The bank is mainly clay, although farther back the soil is sand practically from the surface down. Rock was expected to be found within 10 ft. below low-water level, the latter being El. 475. It was actually encountered at El. 462.5.

The shoe of the pier was set June 22, 1915, on an excavated bench at El. 487. Forms for the chamber, built on the shoe, were then concreted to a level 6 ft. above the cutting edge, which formed the chamber and roof. Two further 6-ft. lifts were concreted, the pier being allowed to settle during this time with a small amount of hand excavation inside to level it up. On July 17 excavation through the shaft by orangepeel was begun.

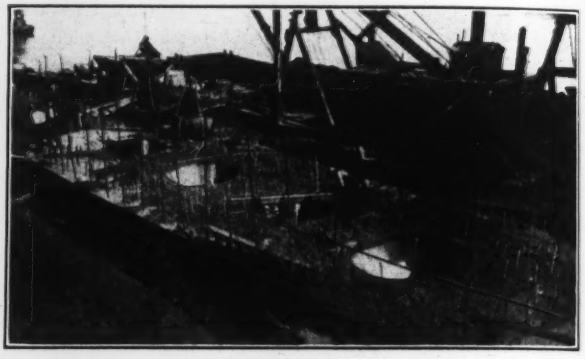
On account of the slope of the bank the contractor set the shoe 7½ in. landward of true position in order to allow for the riverward shift due to the greater earth pressure on the land side.

Shortly after excavation started, masses of old leaves and much clay were encountered on the river side of the pier. The excavation through this material had to be done by hand, the water being held by pumping. When clear soil was reached the chamber was allowed to flood, and thereafter the entire sinking proceeded by orangepeel buckets through the wells to within 18 in. of rock. Two buckets were used, one handled by a stiff-leg derrick set on the bank above the pier and one handled by a derrick boat working close against the bank.

Sinking went on at the rate of ½ to 2 ft. a day in the early stages. After the cutting was through the clay it was in fine sand, and here it made 2 to 3 ft. in 10 hr., the cutting edge being continually buried about 18 in.

Practically all seepage into the pier chamber came from the inshore side and end, there being numerous springs in the bank. Excavated material on the river bank was probably a factor in holding down the inflow from the river.

On July 28 the final 9-ft. lift of concrete was poured, and with this the pier went down to rock, bringing up Aug. 7. The rock was overlain by a layer of gravel on the downstream half of the pier, ranging from 2 to 3 in. at the middle line to 2 ft. at the downstream end. The pier brought up on this gravel. The chamber was then pumped out and the remaining excavation and a 2-ft. cut into the rock to get good bearing were done by hand.



TOP OF CHAMBER, KENTUCKY SHORE PIER OF SCIOTOVILLE BRIDGE

In this work a single No. 4 Emerson pump was sufficient to keep the chamber clear of water. As the shoe was lowered down during the rock excavation, empty cement sacks were packed under, which rolled up behind the cutting edge and shut off most of the water.

In preparing to concrete the chamber on Aug. 18, the bottom (El. 459.3) having reached sound rock, a drain of short lengths of 3-in. pipe covered with concrete in bags was laid around the cutting edge and carried to a sump under one of the shafts. Two 2-in. siphons not worked to their full capacity took the water from this sump. Two grout pipes down each of the four shafts leading to the cutting-edge drain were put in, and then the working chamber was sealed and the shafts filled. After this, grout was forced down one of the grout pipes, using compressed air as the forcing pressure, until it showed at all other pipes.

The pier as finally landed is within 1 in. of true position, departing a little toward the river, and stands practically plumb, is correct in alignment and at a true right angle to the bridge center line. Thus its total lateral shift was 8½ in. from shore toward river.

The total working period was 62 days. Of this period 19 days of 10 hr. were used in excavation.

The above data were supplied largely by R. T. Robinson, resident engineer. He gives credit for the success of the sinking operations to J. Smith Miller, the contractor's superintendent in charge of the work.

Equipment of Concreting Trains

Two concreting trains, each consisting of a mixer car, four to seven stone cars and two to four cars of sand, have been designed and fitted up by the engineers of the Chicago & Western Indiana R.R. for placing 30,000 cu.yd. of concrete in track-elevation work this season. The entire work involves the elevation of 15 mi. of main and yard tracks in Chicago and necessitates the building of retaining walls and abutments, sand fills, steel bridges and 15 subways. There will be grade separation between passenger and freight traffic. The railway is doing the work by its own forces.

The mixer car is placed in the middle of the train, with the cars of stone at one end, the sand at the other and the cement car behind the sand. This arrangement minimizes the distance that materials must be wheeled, calling for a smaller mixer gang. Placing the mixer car at the head of the train in similar work was described in *Engineering News* of Aug. 12, 1915.

A feature of the present work is the use of cement in bulk.

The mixer car is a 35-ft. flat-car, equipped with a $\frac{2}{3}$-yd. Smith nontilting mixer, 10-hp. vertical engine, 20-hp. vertical boiler, 700-gal. storage tank and 60-gal. feed tank for the mixer. The machinery is housed, the roof of the car being higher at the discharging hopper than at the ends of the car, thus forming an easy incline from the runways on top of the gondola cars to the charging hopper above the mixer. The mixer is located about 8 ft. from one end of the car and faces the end (Fig. 2). It discharges the concrete into a swiveling chute, which may be swung to discharge from the end or from either side of the car. This arrangement of pouring at different angles, or from either end of the train, eliminates the necessity of turning the mixer car (as required with other types) and makes a considerable saving in work-train service.

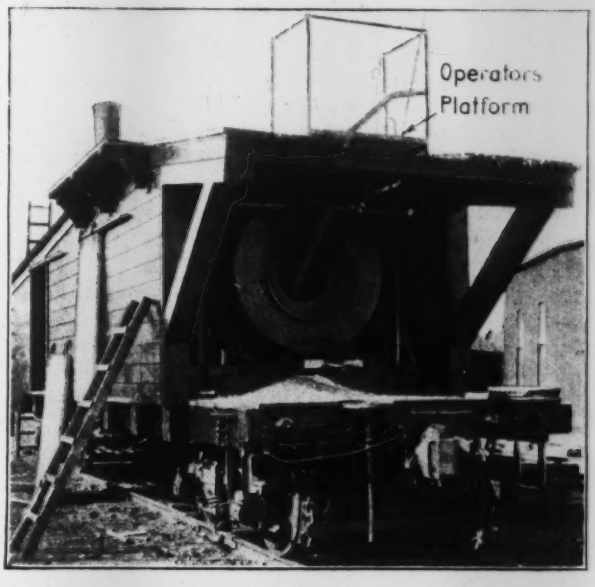


FIG. 2. HEAD OF CONCRETE-MIXER CAR AS USED ON CHICAGO & WESTERN INDIANA R.R.

The chute has intermediate openings, so that concrete can be discharged at different points. A man on top of the car regulates the charging of the mixer, the supply of water and the dumping of the concrete. Usually the mixer trains stand on trestles and the concrete is spouted to the forms for the abutments and piers beneath, as shown in Fig. 1. For the upper part of the piers it has been necessary to elevate the concrete, a crane and bucket being used to place the concrete in the forms.

FIG. 1. CONCRETING TRAIN PLACING THE FOUNDATIONS FOR BRIDGE ABUTMENTS AND RETAINING WALLS; CHICAGO & WESTERN INDIANA R.R.

The mixer car is designed to carry a tower and hoisting engine if required, but as yet this has not been found necessary. A valuable feature of the car is a powerful winch head for a cable, which is anchored ahead. This enables the mixer car to move the train along as the work progresses, thus dispensing with the constant attendance of locomotive and crew.

Each train is placing at the rate of from 20 to 30 cu.yd. per hour, with a monthly total for both trains of 11,000 yd. of concrete. The mixer trains are switched during the night by a regular night crew. Part of the mixer gang is called at 6 a.m., so as to have all chutes and runways placed before 7 a.m., when the full concreting gang starts work.

The work is under the direction of E. H. Lee, Vice-President and Chief Engineer of the Chicago & Western Indiana R.R.; F. E. Morrow, Assistant Chief Engineer; V. R. Walling, Principal Assistant Engineer, and C. E. Minor, Assistant Engineer in Charge.

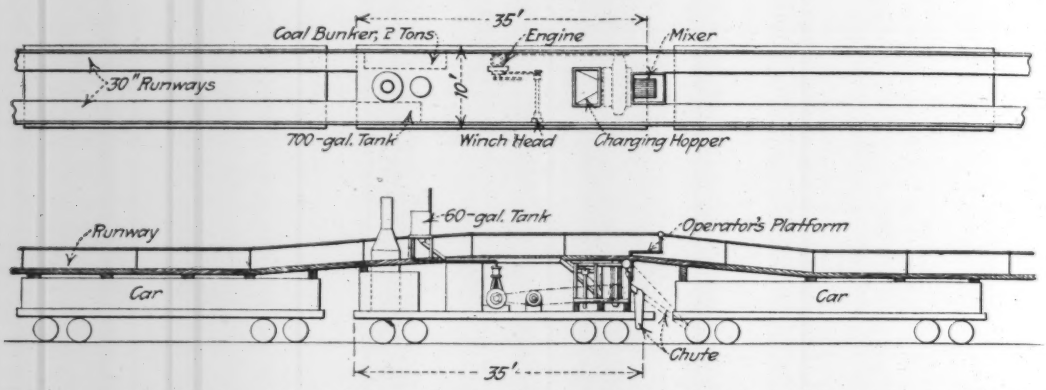
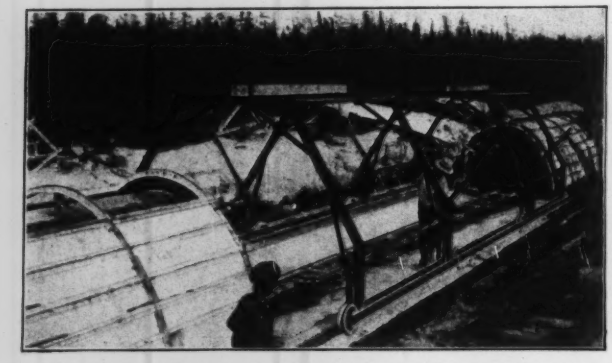


FIG. 3. CONCRETING TRAIN FOR TRACK-ELEVATION WORK; CHICAGO & WESTERN INDIANA R.R.

Traveler for Moving Steel Forms of Water Conduit

Light steel travelers are used to move ahead the arch forms of the Greater Winnipeg water-supply aqueduct now under construction for Winnipeg, St. Boniface, Transcona and several adjacent rural municipalities in Canada. The travelers which handle the interior forms run on a 2-ft.-gage track laid on blocks upon the invert floor. The forms are carried on jacks which form a part of the traveler, and are lined up by turnbuckles on rods which are hinged to the traveler frame. By this method a full arch section of forms 45 ft. in length can be moved at a time. As soon as a section of interior forms is placed, the traveler is run out from under it and the forms are bolted up.

The exterior forms are in 5-ft. sections, which are bolted together to form the full 45-ft. length. These forms are handled variously by the different contractors. In some cases they are taken apart and moved by hand; in others they are lifted as a unit and swung forward by a derrick, while in still other instances a special carrier is employed which straddles the whole construction in the trench, as shown in the illustration. In this case the traveler running on an auxiliary track outside the arch, picks up the outside form (45 ft. long) and transports it to the next section. To remove the outside form, it is suspended by hooks from the roof of the traveler and the sides of the form are connected to the traveler by ratchets operated by long handles. Tightening the ratchets lifts and loosens the form from the hardened concrete. The traveler was built in Winnipeg for the Winnipeg Aqueduct Construction Co.



TRAVELER MOVES FORMS IN COMPLETE SECTIONS WITHOUT DISTURBING ALIGNMENT

Building an Oil-Storage Plant Under Difficulties

A new fuel-oil storage plant has been completed in Providence, R. I., for the Mexican Petroleum Co.—the first of several plants to be built in that locality for supplying oil to various mills. Owing to the small tract of land available on the water front, a number of engineering difficulties were encountered.

Two steel storage tanks were decided upon—one 144½ ft. in diameter and the other 94½ ft. These were placed 3 ft. above mean water, and owing to the unsatisfactory ground, this was excavated to mean high water. Then 55-ft. piles were driven to refusal—700 for tank No. 1 and 500 for tank No. 2. The piles were cut off 6 in. above mean high water, and a 3-ft. slab of concrete was laid on them. In placing the concrete a narrow-gage track was laid, and steel dump cars were run from a ¾-yd. cube mixer. As high as 125 cu.yd. was laid in a 10-hr. day.

Fire walls being necessary, for the larger tank an earth bank was thrown up to 16 ft. above mean high

water by a revolving steam shovel working inside the ring. For tank No. 2 a concrete retaining wall was laid from mean high water up to 12 ft. above; 35- and 40-ft. piles were driven in the ground underneath at 3-ft. centers.

A concrete pump house was built with foundations at mean high water level. The bottom was rod-reinforced,

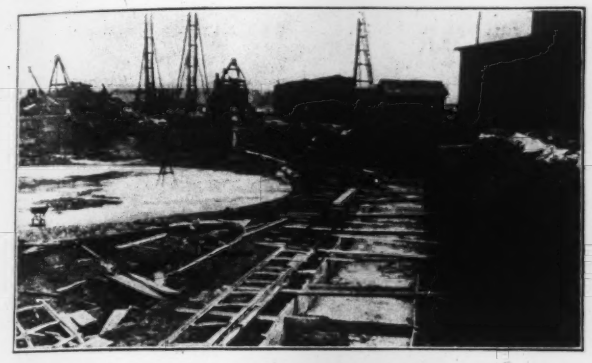


FIG. 1. TANK FOUNDATIONS AND RETAINING WALL. PROVIDENCE OIL-STORAGE TANK

and the bottom and sides were waterproofed. The waterproofing was carried 6 ft. up the walls since the natural surface of the ground was that much above the floor.

As the soil on the water-front side was clay with an underlying layer of fairly soft mud on an inclined hardpan bottom, precautions were taken to prevent sliding. Five rows of piles on 5 ft. 9 in. centers were driven and tied together on top with a reinforced-concrete slab. Anchor rods in the concrete were tied to a close-sheathed timber bulkhead with brace piles. This slab also acts as a foundation for part of the firewall of tank No. 1.

There is a 10-in. pipe line on the upstream side of the dock with 8-in. extensions to both tanks. These serve as charging lines for the plant and loading lines for barges and oil-burning vessels. Screw couplings were used except where flange couplings were necessary. Notwithstanding intricate piping in the pumphouse, the lines are reported absolutely tight. Supply pipes were laid from the pumphouse to a tank-car loading rack placed for overhead loading of five cars at once. An extension goes to an automobile loading rack. In the pumphouse two steam suction pumps were connected to draw from both tanks. The pumps can be worked separately, and valves are placed so that each pump can be repaired without closing down the plant.

The oil is of 14° Bé. specific gravity. It was necessary to run steam mains in the tanks and pipe lines, and steam is supplied by two 70-hp. oil-burning boilers. Instead of covering the floor of the tanks with steam coils as is customary, three sets of coils were placed before the suction pipe. These have a heating surface sufficient to liquefy about 500 gal. per min. The tanks were equipped with foam-system fire extinguishers.

In the construction of the plant Frederic Ewing represented the Mexican Petroleum Co. Ellis & Hauck, of Providence, were the engineers.

A Simple Accounting System for Highway Maintenance

Maintenance cost accounting is receiving much study from highway engineers, because it is realized that the results of such cost analysis and the conclusions drawn from it are the only way of solving the problem of economic roadbuilding. Failures in the past to arrive at any definite conclusions arise from many causes, but chief of these are a lack of consistent policy in road-maintenance methods and a lack of serviceable maintenance cost records.

A serviceable cost account not only furnishes annual financial statistics in detail, such as are commonly given in state highway reports, but furnishes the responsible engineers with working data throughout the year, so that comparisons can be made of the cost of various types of construction and various maintenance methods for the same service.

With a large office force of clerks and bookkeepers it is possible to build up a great mass of very detailed cost data of unquestioned value if properly digested and used. The trouble is that highway engineers are usually too busy to undertake the analysis of any large accumulation of material, and hence its usefulness is often open to question. Simplicity and utility should be the aims, and some practical use should be made of the data once accumulated. To meet these ends the cost-keeping system of the maintenance division of the Ohio State Highway Department serves admirably. Special effort has been made to eliminate all unnecessary detail.

The first point considered is the road unit to be used in cost keeping. Each through road is designated by name or number, and then further subdivision into sections of convenient length is made. This section length is determined by traffic, geographic conditions, and type of pavement. It ranges up to 8 or 10 mi. Natural

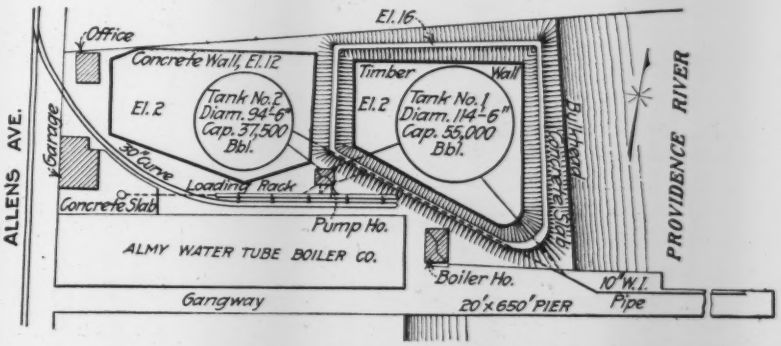


FIG. 2. PLAN OF FUEL-OIL STORAGE PLANT, PROVIDENCE, R. I.

features such as corporation lines, cross-roads or rivers are ordinarly selected as section termini.

The first step is the preparation of estimates for maintenance and repairs before the beginning of each season. These estimates are assembled on blank forms containing the following headings: Highway number, Section number, Length, Type, Nature of repairs needed, Bituminous material required, Division of the estimated cost between county and state, and Total cost.

The elements used in routine are the usual requisitions, the material bills or statements, daily post-card reports,

biweekly payrolls, summarized material reports and final summaries of labor and materials for the completed job. Each bill receives rubber-stamp impressions as follows:

M & R.....
Co. .....
I. C. H. No.....
Sec. .....

Roadbed ..... $
Surface ..... $
Bridges and culverts $
Equipment ..... $
Superintendence .... $
Total ..... $

Bills for all material, equipment, etc., are stamped, and the distribution of cost is made at once in the field by the superintendent. The bills are then forwarded in duplicate to the Highway Department office and filed. Triplicates are kept by the superintendent and are entered on a final material record sheet for the entire section of road. These sheets contain the following data: Item number, Parties furnishing material or service, Material received or service rendered, Date ordered, Car initial and number, Date delivered, Date unloaded, Quantity (superintendent's report, company's report), Cost (unit, total), Date invoice approved. On the reverse side a distribution of the cost of each item is made as on the bills.

No..... **DAILY REPORT** I. C. H. No.....
Repair of
.....Road, Section.....
.....County.

	Teams	Single Horses	Supt. For.	Men			Roller		
Number Employed									
Total Hours									
Rate per Hour									

	Kind of Work Done	Station to Station	Cu. or Sq. Yards	Team Cost	Single Horse Cost	Man Cost	Roller Cost		
Roadbed	Heavy Earth Work								
	Shoulders and Ditches								
Surface	Surfacing								
	Bituminous Work								
	Hauling								
	Unloading								
	Culverts and Bridges								
	TOTALS								

Material Received **Car Initial and No.**

.....,.....
.....,.....
.....,.....

Date.....19.....

.....
Superintendent.
Foreman.

DAILY WORK CARD, OHIO STATE HIGHWAY DEPARTMENT

The daily-report post card is shown in the accompanying illustration. On the reverse side are the printed address and blanks for the following entries: Time arrived on work, Quit work, Weather, Remarks. The biweekly payroll is of the usual type. It is sent to the Highway Department office in duplicate and contains the signatures and addresses of the payees.

The final record of expenditures for maintenance and repair of a section of road is made up in the Highway Department office from the data contained in the payroll and material report; the daily post-card reports and the original bills are the checks. One side of the final cost sheet is identical with the material sheet except that the columns "Date Delivered" and "Date Unloaded" are omitted. On the reverse side are the following four entries, each with two columns, one headed "Labor" and the other "Material": Roadbed, Surface, Bridges, Equipment. There is a column for superintendence costs and one for remarks. This summary is a detail record in concrete usable form. The sheets are 13¾x8½ in., for filing in a loose-leaf binder.

The heading "Roadbed" is intended to cover such operations as cleaning ditches, repairing shoulders, cutting grass, etc., which in many instances are not separated from the maintenance cost for the pavement proper. In this scheme pavement maintenance comes under the heading "Surface."

The State Highway Commissioner of Ohio is Clinton Cowen, and the Deputy Commissioner in charge of repair and maintenance is A. H. Hinkle, from whom the foregoing information was obtained.

Two Steam Shovels in One Cut

Opening a new gravel pit on the property of the Atwood-Davis Sand Co., of Beloit, Wis., called for a through cut ½ mi. long and 38 ft. deep. Two steam shovels were employed to bring the cut to full width—55 ft. at the bottom and 140 ft. at the top. Fig. 2 shows a 70-ton Vulcan equipped with a 3-yd. dipper, preceded at the right by an 18-B Bucyrus having a ⅞-yd. dipper. Both shovels load the same hopper cars, as shown in

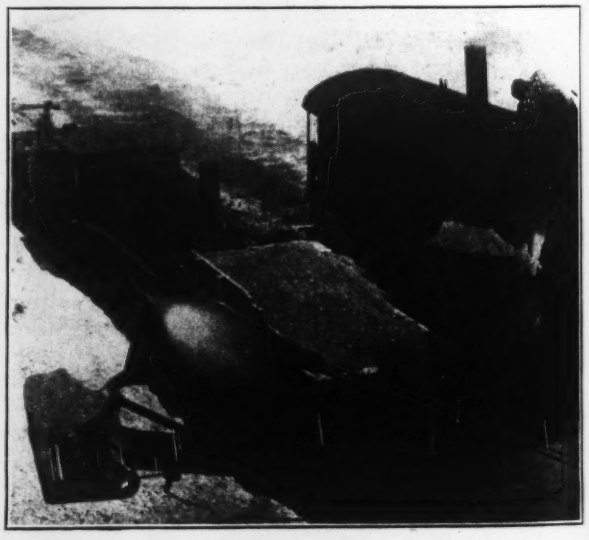


FIG. 1. A SMALL BUCYRUS AND A 70-TON VULCAN LOADING THE SAME CAR

FIG. 2. TWO STEAM SHOVELS DIGGING GRAVEL IN A 38-FT. CUT, ATWOOD-DAVIS SAND CO., BELOIT, WIS.

Fig. 1. A 22-yd. car is loaded in 2½ min., according to the *Excavating Engineer,* and the average output is 45 cars in 10 hr.

The revolving shovel has tractor wheels and stands on three 5½x14-ft. timber floats, 6 in. thick. The floats are blocked up over the loading track. While waiting for empties the revolving shovel overcasts in front of the larger shovel, in order to keep ahead of the latter.

The cars are drawn by a 55-ton standard-gage locomotive. The tender was lengthened to carry on its rear end a coal bunker having capacity for two days' supply for the shovels. This scheme makes their operation as continuous as desired. The two-shovel arrangement was planned out by George B. Harker, superintendent of the sand company.

Table of Feet in Decimals of a Mile

The accompanying table, computed by N. J. Brady, Detroit, Mich., can save a large total of time in railway and road calculations. It is well worth space in the engineer's notebook.

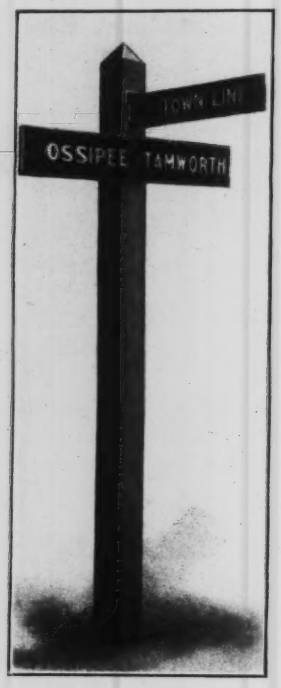
TABLE OF FEET IN DECIMALS OF A MILE

Miles	0.000 Ft.	0.001 Ft.	0.002 Ft.	0.003 Ft.	0.004 Ft.	0.005 Ft.	0.006 Ft.	0.007 Ft.	0.008 Ft.	0.009 Ft.
0.00	....	5	11	16	21	26	32	37	42	48
0.01	53	58	63	69	74	79	84	90	95	100
0.02	106	111	116	121	127	132	137	143	148	153
0.03	158	164	169	174	180	185	190	195	201	206
0.04	211	216	222	227	232	238	243	248	253	259
0.05	264	269	275	280	285	290	296	301	306	312
0.06	317	322	327	333	338	343	348	354	359	364
0.07	370	375	380	385	391	396	401	407	412	417
0.08	422	428	433	438	444	449	454	459	465	470
0.09	475	480	486	491	496	502	507	512	517	523
0.10	528	533	539	544	549	554	560	565	570	576
0.11	581	586	501	597	602	607	612	618	623	628
0.12	634	639	644	649	655	660	665	671	676	681
0.13	686	692	697	702	708	713	718	723	729	734
0.14	739	744	750	755	760	766	771	776	781	787
0.15	792	797	803	808	813	818	824	829	834	840
0.16	845	850	855	861	866	871	876	882	887	892
0.17	898	903	908	913	919	924	929	935	940	945
0.18	950	956	961	966	972	977	982	987	993	998
0.19	1003	1008	1014	1019	1024	1030	1035	1040	1045	1051
0.20	1056	1061	1067	1072	1077	1082	1088	1093	1098	1104
0.21	1109	1114	1119	1125	1130	1135	1140	1146	1151	1156
0.22	1162	1167	1172	1177	1183	1188	1193	1199	1204	1209
0.23	1214	1220	1225	1230	1236	1241	1246	1251	1257	1262
0.24	1267	1272	1278	1283	1288	1294	1299	1304	1309	1315
0.25	1320	1325	1331	1336	1341	1346	1352	1357	1362	1368
0.26	1373	1378	1383	1389	1394	1399	1404	1410	1415	1420
0.27	1426	1431	1436	1441	1447	1452	1457	1463	1468	1473
0.28	1478	1484	1489	1494	1500	1505	1510	1515	1521	1526
0.29	1531	1536	1542	1547	1552	1558	1563	1568	1573	1579
0.30	1584	1589	1595	1600	1605	1610	1616	1621	1626	1632
0.31	1637	1642	1647	1653	1658	1663	1668	1674	1679	1684
0.32	1690	1695	1700	1705	1711	1716	1721	1727	1732	1737
0.33	1742	1748	1753	1758	1764	1769	1774	1779	1785	1790
0.34	1795	1800	1806	1811	1816	1822	1827	1832	1837	1843
0.35	1848	1853	1859	1864	1869	1874	1880	1885	1890	1896
0.36	1901	1906	1911	1917	1922	1927	1932	1938	1943	1948
0.37	1954	1959	1964	1969	1975	1980	1985	1991	1996	2001
0.38	2006	2012	2017	2022	2028	2033	2038	2043	2049	2054
0.39	2059	2064	2070	2075	2080	2086	2091	2096	2101	2107
0.40	2112	2117	2123	2128	2133	2138	2144	2149	2154	2160
0.41	2165	2170	2175	2181	2186	2191	2196	2202	2207	2212
0.42	2218	2223	2228	2233	2239	2244	2249	2255	2260	2265
0.43	2270	2276	2281	2286	2292	2297	2302	2307	2313	2318
0.44	2323	2328	2334	2339	2344	2350	2355	2360	2365	2371
0.45	2376	2381	2387	2392	2397	2402	2408	2413	2418	2424
0.46	2429	2434	2439	2445	2450	2455	2460	2466	2471	2476
0.47	2482	2487	2492	2497	2503	2508	2513	2519	2524	2529
0.48	2534	2540	2545	2550	2556	2561	2566	2571	2577	2582
0.49	2587	2592	2598	2603	2608	2614	2619	2624	2629	2635

Miles	0.000 Ft.	0.001 Ft.	0.002 Ft.	0.003 Ft.	0.004 Ft.	0.005 Ft.	0.006 Ft.	0.007 Ft.	0.008 Ft.	0.009 Ft.
0.50	2640	2645	2651	2656	2661	2666	2672	2677	2682	2688
0.51	2693	2698	2703	2709	2714	2719	2724	2730	2735	2740
0.52	2746	2751	2756	2761	2767	2772	2777	2783	2788	2793
0.53	2798	2804	2809	2814	2820	2825	2830	2835	2841	2846
0.54	2851	2856	2862	2867	2872	2878	2883	2888	2893	2899
0.55	2904	2909	2915	2920	2925	2930	2936	2941	2946	2952
0.56	2957	2962	2967	2973	2978	2983	2988	2994	2999	3004
0.57	3010	3015	3020	3025	3031	3036	3041	3047	3052	3057
0.58	3062	3068	3073	3078	3084	3089	3094	3099	3105	3110
0.59	3115	3120	3126	3131	3136	3142	3147	3152	3157	3164
0.60	3168	3173	3179	3184	3189	3194	3200	3205	3210	3216
0.61	3221	3226	3231	3237	3242	3247	3252	3258	3263	3268
0.62	3274	3279	3284	3289	3295	3300	3305	3311	3316	3321
0.63	3326	3332	3337	3342	3348	3353	3358	3363	3369	3374
0.64	3379	3384	3390	3395	3400	3406	3411	3416	3421	3427
0.65	3432	3437	3443	3448	3453	3458	3464	3469	3474	3480
0.66	3485	3490	3495	3501	3506	3511	3516	3522	3527	3532
0.67	3538	3543	3548	3553	3559	3564	3569	3575	3580	3585
0.68	3590	3596	3601	3606	3612	3617	3622	3627	3633	3638
0.69	3643	3648	3654	3659	3664	3670	3675	3680	3685	3691
0.70	3696	3701	3707	3712	3717	3722	3728	3733	3738	3744
0.71	3749	3754	3759	3765	3770	3775	3780	3786	3791	3796
0.72	3802	3807	3812	3817	3823	3828	3833	3839	3844	3849
0.73	3854	3860	3865	3870	3876	3881	3886	3891	3897	3902
0.74	3907	3912	3918	3923	3928	3934	3939	3944	3949	3955
0.75	3960	3965	3971	3976	3681	3986	3992	3997	4002	4008
0.76	4013	4018	4023	4029	4034	4039	4044	4050	4055	4060
0.77	4066	4071	4076	4081	4087	4092	4097	4103	4108	4113
0.78	4118	4124	4129	4134	4140	4145	4150	4155	4161	4166
0.79	4171	4176	4182	4187	4192	4198	4203	4208	4213	4219
0.80	4224	4229	4235	4240	4245	4250	4256	4261	4266	4272
0.81	4277	4282	4287	4293	4298	4303	4308	4314	4319	4324
0.82	4330	4335	4340	4345	4351	4356	4361	4367	4372	4377
0.83	4382	4388	4393	4398	4404	4409	4414	4419	4425	4430
0.84	4435	4440	4446	4451	4456	4462	4467	4472	4477	4483
0.85	4488	4493	4499	4504	4509	4514	4520	4525	4530	4536
0.86	4541	4546	4551	4557	4562	4567	4572	4578	4583	4588
0.87	4594	4599	4604	4609	4615	4620	4625	4631	4636	4641
0.88	4646	4652	4657	4662	4668	4673	4678	4683	4689	4694
0.89	4699	4704	4710	4715	4720	4726	4731	4736	4741	4747
0.90	4752	4757	4763	4768	4773	4778	4784	4789	4794	4800
0.91	4805	4810	4815	4821	4826	4831	4836	4842	4847	4852
0.92	4858	4863	4868	4873	4879	4884	4889	4895	4900	4905
0.93	4910	4916	4921	4926	4932	4937	4942	4947	4953	4958
0.94	4963	4968	4974	4979	4984	4990	4995	5000	5005	5011
0.95	5016	5021	5027	5032	5037	5042	5048	5053	5058	5064
0.96	5069	5074	5079	5085	5090	5095	5100	5106	5111	5116
0.97	5122	5127	5132	5137	5143	5148	5153	5159	5164	5169
0.98	5174	5180	5185	5190	5196	5201	5206	5211	5217	5222
0.99	5227	5232	5238	5243	5248	5254	5259	5264	5269	5275

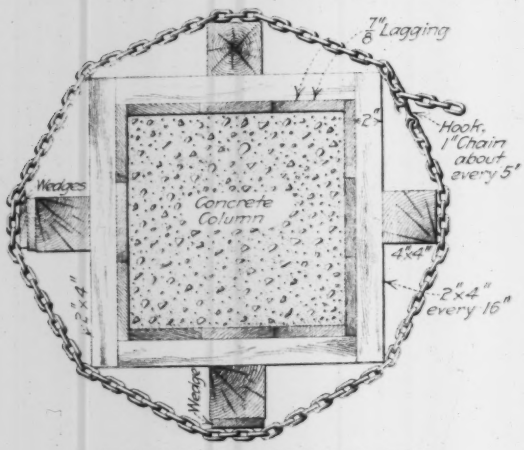
NOTES

Marking Through Highway Routes so that the stranger tourist may readily follow them to his destination without stopping at every branch or crossroad is done in an effective but simple way in New Hampshire. There the difficulty of keeping to the main road is increased because all the roads are of gravel and there is no pavement to follow. Three through routes lead from the Massachusetts state line to the White Mountain country. These are designated both on the map and on the ground by distinctive colors. The Merrimac Valley road is shown green, the East Side road orange, and the West Side road blue. This same color scheme is carried out on the road. At every crossroad or branch three telephone poles each side of the intersection are painted with a band of the color assigned to the highway, inclosed in narrower white bands. To reassure the nervous stranger that he is still on the right road, even where there are few intersecting roads, the end guard-rail posts of each bridge and culvert also receive a color band. The same color scheme is carried out at each crossing of a town line, where signs like that shown in the accompanying illustration are erected, the letters in white and the background of the distinctive road color. There are two east and west through roads marked in a similar manner, the colors being red and brown, respectively. An especially commendable feature of the scheme is that the routes are similarly marked through towns and villages—a plan which saves motor tourists a great deal of annoyance.



NEW HAMPSHIRE TOWNSHIP HIGHWAY SIGN

Column Forms with Chain Ties—On the large cotton warehouse and terminal now under construction at Atlanta, Ga., a novel method of holding the reinforced-concrete column forms is being used. The accompanying section through one of the columns will illustrate the principle. The usual lagging is



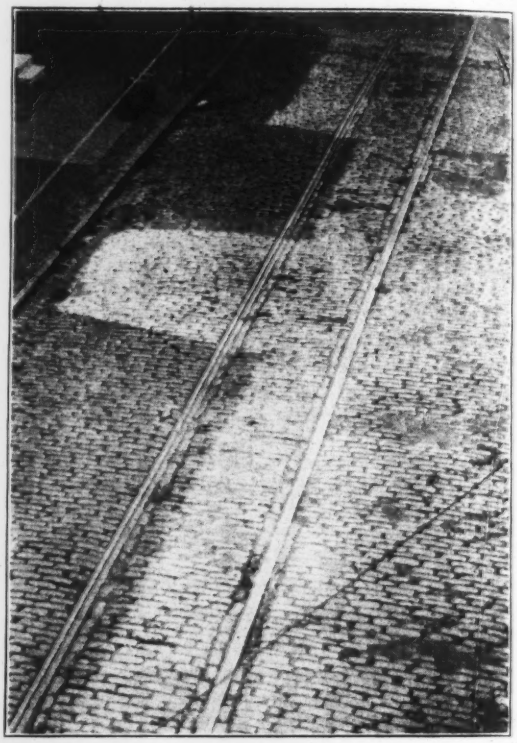
CHAIN TIES ON COLUMN FORMS

Chain shown at walepiece; usual practice is between wales

spiked to 2x4-in. wales spaced every 16 in. vertically. These wales are held in place by vertically placed 4x4's centered on the wales as shown and running the whole length of the column. The 4x4-in. sticks in turn are held tight by chains, spaced about every 5 ft., which are wrapped tight around the form and hooked as shown to complete the circuit. Wedges are then driven where necessary to make the whole form tight. After the concrete has set, the wedges are driven out and the whole form is easily loosened.

Decimals of an Acre in Square Feet—Attention has been called to numerous small errors in the table of decimals of acres in square feet in "Engineering News," of Oct. 7, 1915, p. 702. The number of square feet given for 0.117 acre is 5,097 instead of 5,079 as printed. The other errors are of 1 ft. only to 0.5 acre, and beyond there in many cases the error is 2 ft. B. F. Sperow, of the Carolina, Clinchfield & Ohio Ry., has discovered about 400 such errors. The original table was computed on a computing machine and it seems probable there was some systematic error of setting.

Engineering Photography has been developed to meet many special purposes, such as photosurveying, and not the least important is to furnish testimony in lawsuits, etc. Largely to meet this latter purpose Geo. A. Seip, a professional photographer of Philadelphia, has constructed a camera that can be suspended from a rope strung across a street and



AËRIAL PHOTOGRAPH OF STREET PAVEMENT TO SHOW DEFECTS

operated by clockwork in the camera. The accompanying illustration is from a photograph of a street pavement; it is intended to demonstrate to the lay mind that the pavement is mighty poor. Accompanying this photograph were two enlargements to bring out particular features. While there is nothing new in aërial photography, the scheme of suspending a camera on a rope across a street between two buildings has some novelty.

Low Bidder Made Mistake but Gets Contract—A public-works contract has just been awarded in New York City to a bidder who declared that he had made a mistake in his figures and therefore desired to withdraw his bid (after opening). The contract is for the installation of tracks on the White Plains Road extension of the Lenox Ave. subway. The lowest bidder was the Coast and Lake Contracting Corporation, at $53,930.50. The next lowest bidder was the Southeastern Construction and Engineering Corporation, at $101,205.86, and the other bids ranged up to $137,290.67. After the bids had been opened the low bidder advised the Public Service Commission that he desired to withdraw, as he had made a mistake in his figures, but the Commission, following its usual policy of awarding contracts to the lowest bidder, made the award, so as to give the Coast and Lake Corporation a chance to accept or reject the work.

Editorials

Good Wishes for 1916

To each and every one of its readers *Engineering News* extends its greetings and good wishes for the New Year.

Few engineers in this country will feel any regret over the final passing of the year 1915. One must go back more than a generation to find a year of harder times for those engaged in civil-engineering construction. There has been little complaint, however, for people have involuntarily contrasted the fortunate condition of this country with the conditions prevailing over a large part of the civilized world.

Fortunately the present business outlook for the United States is vastly better than that of a year ago. It is true that the unprecedented events of the war have often proved the predictions of the wisest economists and financiers to be at fault and that the revolutionary changes which seem to be ahead of us are so many and so complex that no conservative man is willing to make any definite prediction as to the conditions which will prevail very far in the future. The immediate outlook, however, is for a period of business prosperity and activity such as the United States has not known for many years, and many lines of wholesale and retail trade and certain industries such as iron and steel production are already in the midst of a boom period.

This revival of general business has already had a marked influence in stimulating work in various fields of civil-engineering construction. There is no longer difficulty in finding money to finance new enterprises of real merit. The restoration of confidence in the banking and investment community has been a notable feature of the past six months and is one of the most favorable indications that 1916 will be a far better year for engineers than was the year just closing.

It is worth emphasis in this connection that the engineers who will profit most from the revival of engineering activity will be those who have kept themselves abreast of the times and are able to meet the changing conditions and demands in the field of engineering service. During the trying year now closing there has been more emphasis than ever before upon the need for efficiency in the conduct of engineering operations.

With all the exaggerations in connection with the efficiency movement and with all the drawbacks due to the work done by some of the amateur efficiency experts, there can be no doubt that real efficiency in the conduct of all productive enterprises is better understood and appreciated than ever before.

The engineer or the constructor who fails to keep himself well posted on the improvements continually being made in his field of work and on the relation of his work to other fields of industrial and economic activity is very apt to find himself beaten in the race of competition by some better-equipped rival. The better the service that the engineering profession can render to the public, the better in the long run will be its chances for continued and profitable employment.

Too Many Highway Meetings

Why should there be two separate national organizations of highway engineers, each holding an annual convention to which all highway engineers the country over are invited and to which all manufacturers of highway supplies and machinery are urged to bring exhibits? The question has been asked with increasing emphasis during the last three or four years by highway engineers all over the country, who would like to attend one convention a year at which the leading men of the industry were assembled, but who cannot and will not afford the time and expense necessary to attend two. The question has been asked with even greater emphasis by the firms dealing in highway supplies and machinery, many of whom have declared that they will no longer undergo the heavy expense of making exhibits at the conventions of two rival associations covering the same field. Practically the same group of men visits the two conventions, and this expense is doubled and attendance duplicated.

At the time the American Road Builders' Association was organized a number of prominent engineers gave it their active support in the belief that the older organization, the American Highway Association, was giving too much prominence to the political end of the good-roads movement and was in danger of becoming an organization whose chief aim would be to secure Federal appropriations for road construction.

That danger, if it existed, long since passed away. Each of these societies has come to be primarily an organization of engineers and others actively engaged in road construction. These are the men who constitute the strength of each organization, and it is the papers and discussions from these men that give standing to the meetings of each society. Papers read before one society deal with the same subjects as those read before the other, and often are written by the same authors. The exhibits of road machinery and supplies, which form one of the most important features of the annual convention, are practically identical at each meeting.

Why, then, should the highway engineers and the highway industry continue to support two rival associations, covering practically the same field? Why should there not be one strong association, with such standing that its work would have the same authority as that of the Society for Testing Materials or the Automobile Engineers' Society?

These are the questions which confront the officers of the two societies, and it remains to be seen how they will solve the problem. What seemed to some like an initial step toward coöperation was taken last fall when the two organizations agreed to hold an "International Highway Congress" at Oakland, Calif., in September, under the joint authority of the two. It has developed, however, that the coöperation in the Oakland meeting was not meant to establish a precedent for future meetings. Further, the Oakland meeting was so nearly a failure that it gave little encouragement that joint conduct of meet-

ings, with the two associations continuing their independent existence, was a good solution of the problem.

Another attempt of this sort, however, is now being made. The board of directors of the American Road Builders' Association at a special meeting on Dec. 16 decided to hold a convention in Pittsburgh, beginning Feb. 28, and held out a small olive branch to the rival association, inviting it to hold its convention at the same time and place, the program of the two conventions to be arranged by a joint committee of the two associations. At the same time the directors declared that consolidation of the two associations is "inexpedient" at the present time and that the holding of a joint convention is impracticable. What response the American Highway Association will make to this invitation remains to be seen, but it appears extremely doubtful whether it will consent to have the time and place of its annual convention fixed by the rival association.

One hears no very urgent demand for the holding of a national meeting of highway engineers of all classes at the date proposed. The highway engineers of New England have just attended, in very considerable numbers, an "International Road Congress" at Worcester, which was engineered by the Worcester Chamber of Commerce. In Chicago, on Feb. 16 to 18, there is to be held a second national conference on concrete-road construction, a meeting which, while devoted to one specific class of roadwork, promises to attract a large attendance and to perform a very useful work.

The situation is one which admits of no halfway measures. There is need of a strong, influential, national engineering organization devoted to highway construction and maintenance. Such an organization can be made powerful and prosperous, and room can be found in it for men who are interested in all the different aspects of highway construction. It need not be an organization merely of engineers. But there is not room for two rival organizations in this field. Those who are appealed to for financial and technical support are ready to exclaim, "A plague on both your houses!" It is time that personal differences and preferences were put one side; and while these past differences are doubtless too great to permit either association to commit hara-kiri for the benefit of the other, it ought to be possible to organize a new association on proper lines with independent officers in no way tied up to the rivalries of the past and have the two old associations bequeath to it all their possessions and wind up their existence. Any measure less radical seems little likely to succeed.

A Sinking-Fund Delusion

If a utility company is to recover the loss of capital caused by the depreciation of its plant, the customers must pay for it in the rates charged them for service. This is clear; it is equally obvious that there is no way to lessen the amount which the customers must pay—if the company recovers the loss *in full*. Yet many people, including such an eminent man as the respected Halford Erickson, of the Wisconsin Commission, claim there is a way in which this miracle has been and can be accomplished.

Now there are two general types of plans followed in this country in extracting indemnity for depreciation out of the customer's pocket. First, there are the direct-repayment, or "straight-line," schemes which aim directly to repay the company for the actual annual loss in impaired capital. The second, or "sinking-fund," group of plans takes out of earnings an annuity which would, if put into a true accumulating sinking fund, equal the cost of the depreciating property when discarded. Since obviously reimbursement for depreciation can come only from the customers, if both of these plans really do cover the depreciation loss, either one must cost the customers the same as the other. Claiming that one plan is cheaper than the other is only doing a trick in words or in bookkeeping.

We may see what the trick is from a few of Mr. Erickson's remarks in a paper before the recent Philadelphia Valuation Conference (noted in *Engineering News*, Nov. 18, 1915):

> Without going into details, it can be said that the sinking-fund method employs a more efficient use of the reserve [than the straight-line plan]. Because of such use, the amount the consumers will have to contribute to cover depreciation is less than under the straight-line method.
>
> Where the amounts so provided have been used for necessary and proper renewals and for the accumulation of a reserve for covering the accrued depreciation of the property still in use, no reduction from the cost new, because of depreciation, should be made in determining the fair value for rate making and certain other purposes.

All that Mr. Erickson and others do is to ask the customer to pay more for interest on capital and less for depreciation. The total is unchanged. The "sinking-fund" annuity is less than the actual annual depreciation loss, and the discrepancy is recovered in interest on a plant value larger than the actual present figures. This interest they do not recognize as part of the depreciation indemnity.

If the matter ended there, this use of the sinking-fund computations would harm no one. But the United States Supreme Court has ruled (City of Knoxville vs. Knoxville Water Co., 29 Sup. Ct. Rep. 148) that the company each year is entitled to recover a dollar, above interest and profits, for each dollar by which the plant that year has lost value in service, while present (depreciated) value must be the basis of rates. It is immediately seen how Mr. Erickson's views run counter to the court's dictum in that he does not openly year by year give a company ample indemnity for depreciation losses, and in that he includes a nonexistent and lost element in the value of the plant. It would clarify all our ideas if we abandoned sinking-fund talk and stuck to the simpler direct annual repayment plans for computing the customer's burden.

The objection that many have held against straight-line or direct-repayment plans of handling depreciation reimbursement has been that the early repayments were larger than the real depreciation and in the later years smaller. But the direct-repayment plan can be handled so that depreciation and the repayment therefor go hand in hand. That was done a few years ago by Frederic P. Stearns when he developed his "equal-annual-payment" plan (described in *Engineering News*, Feb. 12, 1914, p. 350). Briefly stated, each annual compensation is made numerically equal to a hypothetical sinking-fund annuity plus the interest accretion of a hypothetical reserve fund. The customers are loaded with exactly the same costs as under the procedure indicated by Mr. Erickson, but everything is correctly labeled, delusions are dissipated, and the law is entirely satisfied.

Reorganizing the Interstate Commerce Commission

Scarcely anyone doubts that the policy of railway regulation by governmental authority is here to stay. Everyone agrees, likewise, that in the interest of both the public and the owners of the railways, and of those who hold the stocks and bonds, government regulation should be honest, intelligent and effective. To carry out the policy of Federal railway regulation, Congress has given to seven men, constituting the Interstate Commerce Commission, authority over the operations of about 250,000 mi. of interstate railways. Congress has further specified in connection with these railways detail duties for the commission which are beyond the physical ability of any seven men not gifted with superhuman powers to perform efficiently and intelligently.

In its annual report just issued the commission declares that the variety and volume of the work already laid upon it make necessary an early enlargement of its membership and legal authority to take final action through subdivisions of its membership, of course under the general authority of the commission as a whole. Bills to effect this have already been introduced in Congress, and the subject is one of pressing public importance.

As is well known, the commission is compelled by law to be both an executive and a judicial body. As a judicial body it has to hold hearings and render decisions. Some idea of the volume of this work may be gained from the statement that the commission has during the year conducted 1,543 hearings, in which 200,438 pages of testimony were taken; 198 of these cases were orally argued, consuming 103 days in sittings.

While the commission, in order to handle this vast mass of judicial work, employs a force of examiners, somewhat as the judges of the Federal Court assign masters to hold hearings and render reports, the decisions must of course be rendered by the commission itself; and on these decisions hang many great commercial interests. The commission also acts in a judicial capacity in conducting investigations, many of which are exceedingly complicated and involved. They require a great deal of time and effort in order that justice shall be done.

The commission receives and files all railway rate schedules, something like 150,000 being filed in the year just closed. It has jurisdiction over the standard classification of freight and over the operations of express companies. An entire division under the commission is engaged in the search for violations of the laws which the commission was created to enforce. The legal division has charge of all the cases in which the commission appears as a party. The commission has control of the accounting systems of the railways; it collects and compiles the official statistics of railway operations; it conducts investigations of important train accidents to determine their causes; it investigates safety devices of various sorts; it examines periodically all the locomotives in the United States to determine their safety for operation. The immense task of valuing all the railways in the United States is in its charge.

The responsibility for the conduct of all this work is laid upon the shoulders of seven men, who, it may be noted, receive a total compensation of $70,000 per annum—a sum no larger than is paid as a salary to the president of a single railway corporation, who is in charge of operations not a twentieth part the extent of those over which the commission holds jurisdiction, and with very much smaller powers.

It is probably not to be expected that Congress will increase the salaries of the Interstate Commerce Commissioners to correspond to what men would receive for equally great responsibilities in private business. It ought at least, however, to revise the salary schedule and bring it up to the mark set by Justice Hughes when as the governor of New York he fixed the salary of the Public Service Commissioners in that state at $15,000 per annum. Such a rate of compensation, in view of the change in the value of the dollar that has taken place and the increase in the cost of living, would be no higher salary than the $10,000 rate that was fixed when the Interstate Commerce Commission was created in 1887.

But more important than an increase of salary is the reorganization of the commission on broad and intelligent lines and in a manner that will enable it to discharge its duties efficiently. The way is open for such a reorganization now, through the changed attitude of railway officers toward the commission. In place of the antagonism and opposition to government control which the railways maintained during the first 20 years or so of the commission's existence, there is now full acquiescence in the idea that railway regulation through commissions is here to stay. With this established there ought to be no dissent from the proposition that an organization of able men adequate to deal with the great task ought to be created.

Fatigue in the Spokane Bridge

The worst bridge accident for some years, the Spokane collapse, presents unexpected fact and unexpected theory. During a generation at least no failure by breaking of eye-bars has been recorded. The few tension failures of recent times were all complicated by large bending stresses, as for example the alarming breakage of suspender rods in the Brooklyn Bridge 14 yr. ago. The Spokane failure is therefore startlingly new even in its main fact. Still more startling is the fact that the break occurred at very low stress—not much over 16,000 lb. per sq.in. even if one bar carried the entire stress. Finally the fact that short crystalline breaks are in evidence is a complete surprise.

Four engineers in reporting on the case blame the break on "granulation" of the bars; they do not state what caused the "granulation." Another engineer, testifying at the inquest, spoke of "fatigue"—that ancient bugbear of bridge engineering. Just this year the reconstruction of the New York elevated railways gives special opportunity to point out that the thousands of tons of iron and steel in that structure have stood 25 to 35 yr. with a history of stress-repetition, vibration and impact probably unparalleled in the history of iron construction. They have never showed any "fatigue" effects, or "crystallization." Most of the old metal is being continued in service in the rebuilt structure, and without doubt is as good as it was at the start.

"Fatigue crystallization" is properly obsolete. But damage to internal structure of metal by wrong heat-treatment, and under certain conditions by mechanical violence, is a reality that needs to come under closer scrutiny than it has in the past.

Letters to the Editor

Cement Joints for Cast-Iron Pipe at Los Angeles

Sir—I was much interested in your editorial article of Nov. 25, 1915, on cement pipe joints, commenting on the paper on the same subject appearing among the regular subjects in the same issue. In connection therewith I would call your attention to *Engineering News* of Dec. 8, 1904, in which appears a lengthy communication from the late James D. Schuyler on the same subject, dealing with some of our experiences in the water-works of the City of Los Angeles, as well as in the Southwest generally.

It has been our universal practice for more than 20 years in the water-works of the City of Los Angeles to lay cast-iron pipe with cement joints; indeed a few of our largest steel lines also, not alone for reasons of economy, but because as a matter of fact we got a better joint and strange as it may seem, fully as flexible a joint as we obtained with lead. We do not claim, however, that the idea originated with us, as it was the common practice in the older water-works, where cement-lined pipes were used, to join them with sleeve joints having cement packing.

The water-works of the City of Los Angeles were begun in 1868, and the writer found the bell end gates packed with cement inserted in the 8-in. cast-iron line that originally formed the trunk line for the city supply. It is the writer's opinion that there is no limit of pressure within the ordinary strength of cast-iron pipe itself precluding the use of cement joints.

In 1895 the water-works department of Los Angeles laid on Hoover St. a 30-in. line of cast-iron pipe that subsequently had to be lowered at three different points for distances ranging from 200 to 800 ft. in length to accommodate the street grade. At one of these places the pipe was lowered nearly 7 ft. at its maximum point of displacement, and this was done without cutting a single joint. Although the pipe wabbled considerably out of alignment in the operation, the seeping leaks caused by the movement all took up automatically without further attention.

I also read with a great deal of interest the contribution of R. S. Lord, in the same issue of your valuable journal, on the subject of wrought-iron pipe couplings, and would say that I have made extensive use both of the Dresser and the Dayton coupling and am firmly convinced of their merit over threaded pipe. The most noted instance of this type of coupling in the writer's practice was in the penstock line of the Upper Division Creek power plant of the Los Angeles aqueduct. This line was 15 in. in diameter, of plain-end lap-welded pipe, coupling together with the type of Dayton coupling shown at Fig. 16 of Mr. Lord's article. We made a marked departure, however, from the ordinary method of using the coupling. Before inserting the triangular-section gasket, neat cement mortar was rubbed into the joint clear around the pipe in the position to be occupied by the gasket, after which the gasket was pulled home in the regular way.

This line has a head at its lower end of 1,266 ft., and the wrought-iron pipe terminates at its upper end in a riveted sheet-steel pipe at a point where the head is about 400 ft. These joints were absolutely tight, not one of them ever showing the least seep; and I am firmly convinced that there is great merit in the use of cement in this connection. This pipe line has been under this constant head since 1908, seven years.

Recently a 12-in. line for natural gas coming into Los Angeles from the Kern River field required the removal of the Dayton couplings, due to some form of carbonization and destruction of the rubber gasket. I firmly believe that if cement had been used in these joints in the manner above indicated, no such trouble would have been experienced, as the cement mortar would have protected the rubber from contact with the injurious elements in the gas.

WILLIAM MULHOLLAND,
Chief Engineer, Bureau of Water-Works.

Los Angeles, Calif., Nov. 30, 1915.

[The article referred to in *Engineering News* of Dec. 8, 1904, gives a large amount of valuable information as to the history of cement joints for pipe and experience with them.—Editor.]

Problem in Sorting Aggregate in Storage Bins

Sir—In supplying graded aggregate for concrete to the several contractors on the 85-mi. aqueduct work, the Greater Winnipeg Water District has operated for the past year a gravel-screening, crushing and mixing plant located at mile 31. In this plant the material is screened into fine, intermediate and coarse (2½-in.) grades, passing directly into bins, from which it is fed through bottom hoppers in definite proportions to a mixing belt. The remixed material is then elevated and distributed by means of a belt conveyor into storage bins located over a loading track. From these storage bins the graded aggregate is loaded directly into 20-yd. air-dump cars and hauled along the District Railway to the various contractors' receiving platforms.

In the operation of this plant we have encountered a difficulty that we have been unable as yet to overcome, and it may be that the experience of some of your readers may help us in this regard. The trouble has been that when the mixed aggregate is dumped from the conveyor belt into the storage bins it naturally cones up and segregates, the fine material staying in the center and the coarse rolling to the outside, with the result that when the bins are emptied the material fed is far from being uniformly graded. We have tried out baffles and a telescopic chute, which is drawn up as the bin is filled, but any method we have as yet devised has not been satisfactory. During the past season we loaded the cars by chuting the material

direct from the conveyor belt over the bins, but this method depriving us of the use of any storage capacity.

I shall be glad to hear if any of your readers have experienced this difficulty, and if they have been able to overcome it in a satisfactory manner. M. V. SAUER,

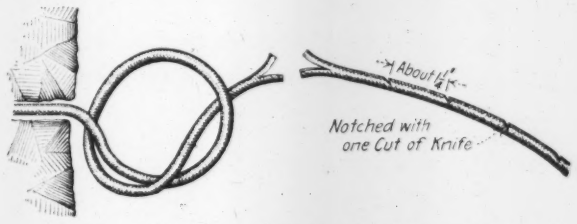
Engineer of Design, Greater Winnipeg Water District.

Winnipeg, Man., Dec. 13, 1915.

Lighting a Fuse with a Fuse

Sir—While not wishing to prolong the discussion on the best way to ignite a blasting fuse, I have a method that I should like to get on record.

First the fuses are arranged so that their cut ends project upward. This may be done by coiling them in a



HOW L. B. CAIN LIGHTS BLASTING FUSES

loose knot. Next, the ends are split for about 3/8 in., exposing the powder. A piece of fuse half as long as the shortest to be fired is notched as is shown in the diagram. The spitter is then lighted and the fuses of the charge are ignited from the successive notches.

The reason for making the spitter one-half the length of the shortest fuse is to give a gage on the time since the first fuse was lighted. Fuse as it is manufactured today is very uniform in its time of burning, so that a glance at the spitter will give a definite idea of the length burned on the first fuse. It is well not to stay longer than the time required to burn one-half the length of the first fuse, but of course this depends on conditions and the length of fuse being used.

This method will be found to be both rapid and convenient. One man can spit, under normal conditions, 18 or 20 fuses in less than one minute when the holes are not scattered too far apart.

I agree with Mr. Martin that short fuses are misplaced economy. LOUIS B. CAIN.

Department of Public Works, Honolulu, T. H.,
Nov. 5, 1915.

Sir—Injecting my little piece into the discussion regarding the different methods of lighting blasting fuses, I will say that I have had marked success in lighting them with a piece of hardwood—preferably oak—about 1 in. in diameter and 1 ft. long, that has been put into a fire until the end is a live coal. I notch the end of the fuses and place a pinch of dynamite therein. The fuse is ignited as soon as the firebrand comes in contact with it. I have lighted as many as 15 charges by this method.

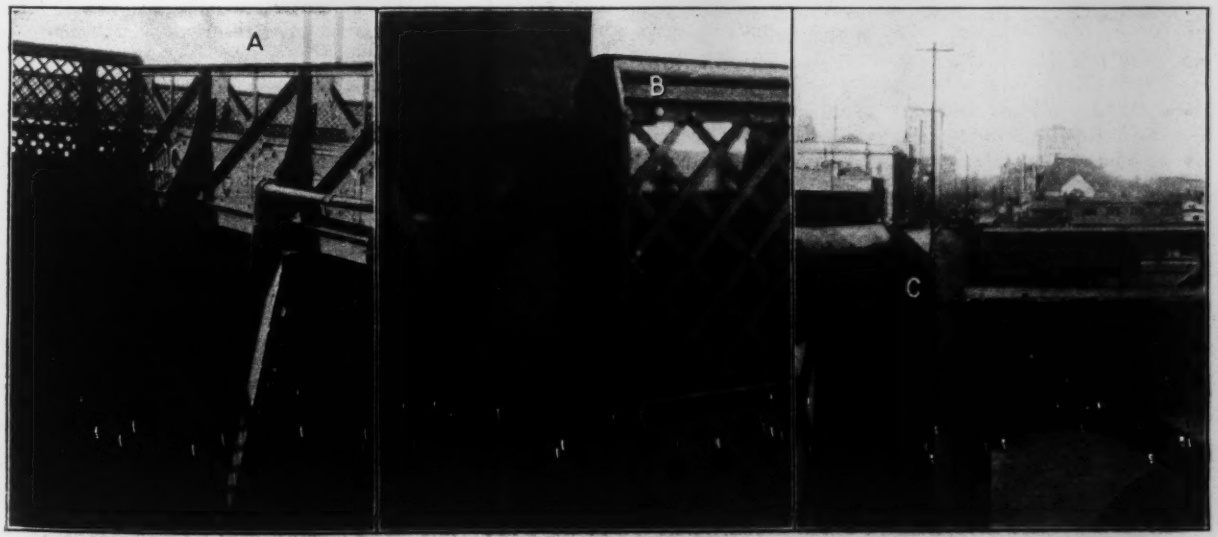
Santa Paula, Calif., Dec. 9, 1915. I. J. GRUNDEL.

Stray Currents on a Bridge

Sir—A year ago when in Youngstown, Ohio, my attention was called to a peculiar condition existing on the Market St. bridge, which spans the Mahoning River valley. The bridge is a steel structure and is about 2,000 ft. long. About midway of its length and about 30 ft. east of it is located the general office of the Republic Iron and Steel Co. This is a brick and iron building rising from the valley below the bridge, and access on a level with the Market St. bridge is had by an iron foot bridge about 6 ft. wide. The guard rail at the top (*A* in the views) is secured to the rail of the main bridge by a single piece of 3/8x1½-in. steel (marked *C*) fastened with a 5/8-in. bolt.

Now the peculiar feature of this bridge to which the writer's attention was called is this: The 5/8-in. bolt referred to (marked *B*) is at all times warm, in fact so warm that the hand can remain in contact but for a moment. This phenomenon is known to almost everybody who has occasion to use the bridge and is shown to visitors as a curiosity.

When asked the probable cause of this heating, bypassers invariably stated that it was due to the vibra-



BRIDGE CONNECTING REPUBLIC IRON AND STEEL CO. OFFICE WITH MARKET ST. VIADUCT, YOUNGSTOWN

tion of the bridge, causing friction between the tightly drawn-up bolts and the rail. The hot bolt has also been featured in one of the local papers, and vibration was given as cause of the heating.

A little thought will make it readily apparent that this could not be the cause. A bolt of that size could not continue to maintain such a tight contact as would be necessary to generate through friction such great heat as is present. I therefore concluded that the only other cause of the heating would be stray currents from the railway tracks crossing the bridge. Not having any means at hand at the time for determining this, I decided to do it at the first opportunity. Having occasion to visit Youngstown a week later, I came prepared with a coarse file and low-reading portable voltmeter. After cleaning the bolt head with the file and filing a clean spot on the ⅜x1½-in. bar and applying the voltmeter leads, a deflection of 1 volt was read. This varied from 0.8 to 1.2 volts, the highest reading being secured when trolley cars were passing at that point.

Lack of time did not permit me to make any more extensive tests to determine the amount of current flowing through the ⅜x1½-in. bar, which undoubtedly was considerable, judging from the amount of heat developed in it. A letter received Dec. 4, 1915, states that the bolt is still hot. Any further information that readers in Youngstown may be able to furnish regarding this would undoubtedly be of interest.

Cleveland, Ohio, Dec. 16, 1915. P. Justus.

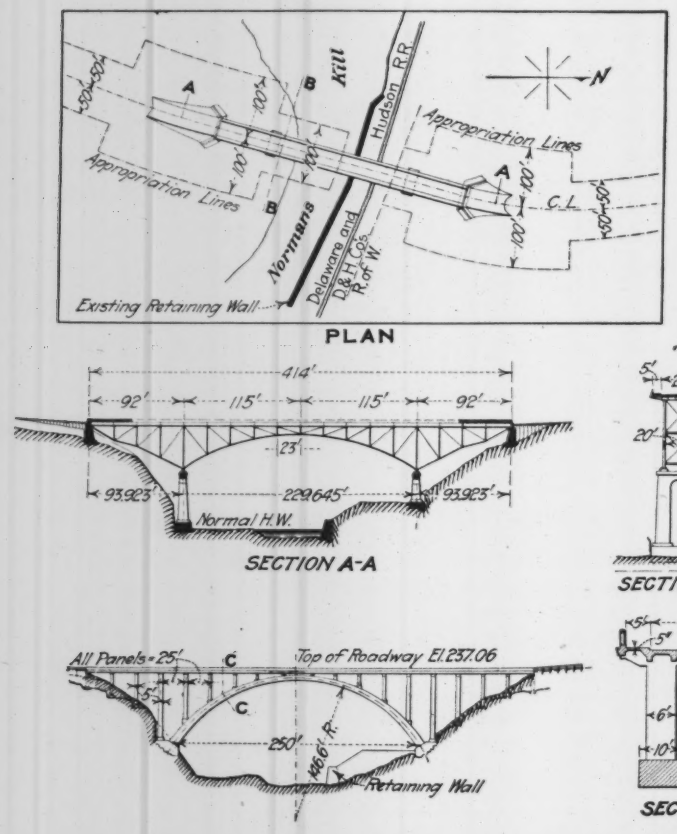
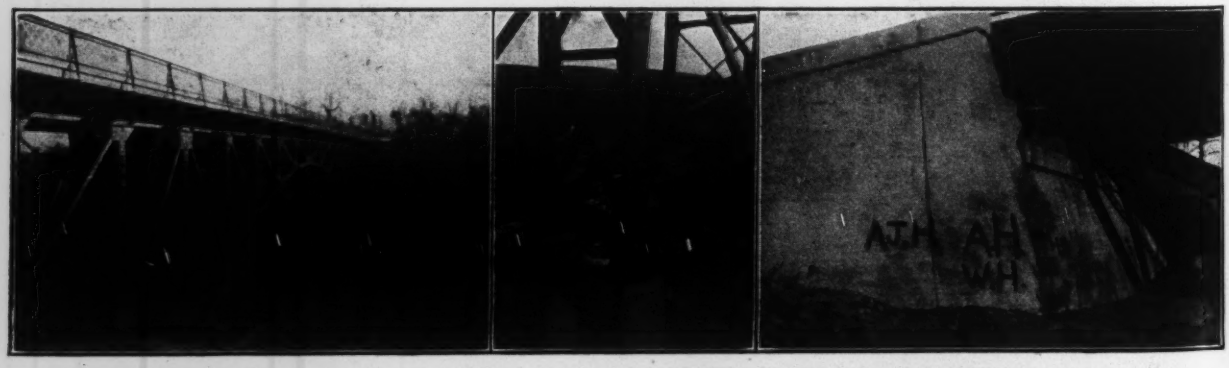


FIG. 1. STEEL AND CONCRETE ARCH DESIGN FOR NORMANSKILL VIADUCT

Normanskill Viaduct; A Second Popolopen Case

Sir—A steel highway bridge, or viaduct, of pleasing design has just been completed near Albany, N. Y., to carry a boulevard across Normanskill Creek, which at the site of this structure traverses a beautiful gorge on its way to the Hudson River. The structure and topography of its site are quite similar to the Popolopen viaduct and gorge shown in your issue of Oct. 28, 1915, and commented upon in your issues of Nov. 4 and 25, 1915. The whole case of the Normanskill viaduct resembles the Popolopen in several ways.

The writer, in February, 1914, as Supervising Engineer, was required to have designs prepared for a bridge over the Normanskill gorge. It was fully realized that a reinforced-concrete arch was the best, and in the long run the most economical, type for the Normanskill site, so an outline design for such a structure (shown in Fig. 1), together with three designs for steel structures, was submitted to the then State Engineer, J. A. Bensel. The total cost of the steel structure was $65,200. The estimated cost of the reinforced-concrete structure was about 17% more; while this difference is not a great sum, lack of funds may have precluded the acceptance of the reinforced-concrete design.



FIGS. 2, 3 AND 4. GENERAL VIEW AND DETAILS, NORMANSKILL VIADUCT

The structure built is shown in Fig. 2. It is a steel cantilever with a curved lower chord, and it provides a highway 25 ft. in width flanked by two sidewalks each 5 ft. wide. The deck, or floor, is of reinforced concrete, affording permanent protection to the structural-steel floor beams and much of the supporting metal of the entire structure. The highway loads assumed were two 15-ton motor trucks, or 100 lb. per sq.ft. of roadway; 80 lb. per sq.ft. was the assumed load on the sidewalks.

W. H. YATES.

52 Wall St., New York City, Dec. 6, 1915.

Railway-Track Maintenance

Sir—In your issue of Dec. 9 a communication signed "Railway" states that no track force can maintain good track where track is composed of defective material. It is admitted that old and decayed track is an evil, and one which it would probably be difficult to eliminate entirely. However, such a condition can be ameliorated when there is an adequate track force, and it is aggravated by a lack of such force.

It has been the writer's observation in the course of practical experience in railway-maintenance work that there are times when new track material is on hand with no labor to insert it in the track, on account of a reduction in force. Ballast has lain on the ties, ties have been stacked on the right-of-way and even new rail and fastenings distributed for months before the forces were increased sufficiently to place the material in the track.

If a minimum track force based, say, on the track-mile be maintained and never decreased in size, our railways would be safer and more comfortable means of transportation.

G. F. SCHLESINGER.

Ohio State University, Columbus, Ohio, Dec. 15, 1915.

NOTES AND QUERIES

Heavy Nickel Plate Girders—Several errors in the article "Record-Breaking Plate Girders for Nickel Plate R.R.," Dec. 9, 1915, p. 1105, should be corrected as follows: In line 3, "four-track" should read "fifteen-track." In line 5, the reference should be to Nov. 4, p. 888. In line 15, "130½ tons" should read "113 tons." In line 17, the Boston & Albany R.R. should be mentioned instead of the New Haven.

Problem in Municipal Accounting—Are paved streets, sidewalks, and bridges proper items to insert in making up a municipal asset and liability sheet? This question is raised by M. J. Guyton, Clerk of the Light and Water Commission of Dublin, Ga. Mr. Guyton is also in a quandary as to whether the fact that the city paid for only one-third of the street pavements and sidewalks and the property owners paid for two-thirds should make any difference in the amount of the entry. He also asks whether unpaved streets are properly listed as a municipal asset and if so, what rule is followed in ascertaining their valuation.

The Use of Streets for Public Markets has met with serious objections from Gus H. Hanna, Commissioner of Street Cleaning of Cleveland, Ohio. In his paper before the recent Worcester Road Congress, Mr. Hanna said: "The greatest source of expense in Cleveland has come not from those who use the street for traffic, but from those who use it as a place of business. A few hundred square feet near a certain street corner cost our department $10,000 to keep clean during the past year. It is the location of a curb market, supposedly a farmers' market, but really the resort of professional hucksters who dispose of provisions that have often become shopworn in adjacent market houses before finding their way to the curb. It would be a small return for the privilege of doing business in the street to require these hucksters to keep their surroundings clean at their own expense, on pain of arrest or forfeiture of their priveleges. My annual report recommends that some method be found of ridding the city of this form of imposition."

General Goethals' Report on the Panama Canal

The annual report of Gen. George W. Goethals, Governor of the Panama Canal, just issued, shows that the total amount which has been expended for the canal, including the balance of appropriations still on hand and available for work now in progress, is $357,456,000. From this total cost there should be deducted receipts from the sale of construction material and equipment, and the value of buildings and plants transferred to the army and the Alaskan Railway Commission without charge, also payments to be made by the Republic of Panama for municipal work in the cities of Panama and Colon. In comparing this figure with the estimate of total cost made in 1908, it should be remembered that the expenditures include a dry dock, two coaling stations and terminal piers which were not provided for in that estimate, and also a payment of over $1,000,000 for employees' injuries, made necessary by laws passed since the estimate was made.

SLIDES IN THE CANAL

The report is dated Aug. 2, 1915, so that it does not cover work on the slides which have since taken place. It is evident, however, that the eventual movement was foreseen of the material which has since slid into the channel. The report states that near Culebra in June, 1915, "the general movement of the bank from Station 1771 to 1796 was noticeable, and it was estimated that 5,000,000 cu.yd. of material were in motion on June 30 on the west side. It is estimated that about 4,000,000 cu.yd. will have to be removed from the east side."

There has been some question among engineers as to why steam shovels have not been employed to supplement the work of the dredges in removing the slides. In this connection the following is of interest:

> An examination of the west bank made subsequent to the break of Oct. 14, 1914, developed the existence of cracks on both banks and the question of resuming steam-shovel operations on both banks was considered seriously but abandoned because the amount of work that could be accomplished by the shovels would be relatively small and the cost excessive. The breaking up of the banks has proceeded so rapidly that this conclusion has been fully justified.

In this connection also the statement as to the relative cost of steam-shovel and dredge excavation is of interest. During the year there was removed by dredging in maintaining the channels through Gaillard cut 4,710,000 cu.yd., at an average division cost of 34.67c. per cu.yd. The average division cost of steam-shovel excavation in that section to June 30, 1914, was 70.66c. per cu.yd. Had it been attempted to do steam-shovel work on the present slides, however, the cost would have been much greater than the sum above stated, due to the large expense of maintaining tracks on the slides.

There is still a good deal of misunderstanding as to the material which is sliding into the canal, many still supposing it to be earth and clay. The report states, however, that of the 6,671,000 cu.yd. removed from the Gaillard cut during the year, 5,559,000 cu.yd. was rock and the balance earth. As showing how this material behaves, the following quotation is of interest:

> On the night of Oct. 14, 1914, a break occurred at East Culebra which completely closed the channel. The entire east bank for a distance of about 2,100 ft., extending back for a distance of about 1,000 ft. from the center line of the canal, settled vertically and the lower strata squeezed into the cut, so that at some points there were only 9 in. of water where prior to the movement there were 45 ft.

This huge slide closed the canal, however, for only six days, when a channel was dredged through it sufficient for the passage of ships. The slide continued to move, however, and the canal was again closed for five days from Oct. 31 to Nov. 4. Four months later it was again closed six days, from Mar. 4 to Mar. 10.

Digging away of the slides is by no means the only work in charge of the dredging division, of which W. G. Comber is the head. At the Pacific end, 542,000 cu.yd. was dredged between deep water in Panama Bay and the Pacific entrance, and about 2,800,000 cu.yd. was dredged from the Balboa inner harbor. At the Atlantic terminal 759,000 cu.yd. was dredged from the Cristobal approach pier channel, and 265,000 cu.yd. of coral rock was excavated.

Water-Supply of the Canal

The water-supply of the Panama Canal was a fruitful subject for argument in the early days of the enterprise. One of the stock arguments of the advocates of the sea-level canal was that the Chagres River would not supply enough water to keep the canal in operation during the dry season. The experience of the dry season of 1915 indicated, however, that the need for anxiety on that score is remote, although it is true that the rainfall during the dry season a year ago was unusually heavy. The rainfall on the surface of the lake during the dry season practically equaled the loss by evaporation. Instead of being obliged to draw down the level of the lake during the dry season to supply water for lockages, enough water was wasted over the spillway during the freshets of Feb. 9, 10 and 11 and Apr. 3 and 4 alone to have raised the lake level 2.95 ft. The water-supply situation of the dry season of 1915 may be presented in tabular form as follows:

	Million Cu.Ft.
Total yield of Gatun Lake watershed	43,924
Evaporation from lake surface	9,427
Used for hydro-electric power	8,312
Used in making 983 lockages and tests	3,724
Used for municipal purposes and by suction dredges	279
Leakage	175
Wasted at the spillway	23,264

The New Dry Dock at Balboa

Dry dock No. 1 is nearly ready for use. This dock is 110 ft. in width at the entrance and 1,044 ft. long from the point of the miter sill to the head. The miter and caisson sills are 39.5 ft. below mean sea level. The dock will contain with the tide at mean sea level 5,265,000 cu.ft. of water. The dock is excavated in rock. The floor is merely a smooth skin of concrete laid over the rock floor after the excavation. The side walls are of gravity section and are connected by a semicircular head. The side walls are reinforced at the back with 70-lb. rails. To prevent hydrostatic pressure accumulating behind the walls, a drain is formed at El. —27.5 ft. on the back of each wall communicating with the interior of the dock by four 8-in. pipes. At the entrance of the dock are a pair of steel miter gates that are identical with the Panama lock gates, except that the bearing surfaces at the miter and quoin ends are of greenheart instead of nickel steel. According to the *Canal Record* of Dec. 8, 1915, the first gate was hung on Nov. 27, and the second gate will probably be hung before the end of the year. In front of the miter gates is a seat for the floating caisson that is used for closing the lock entrance when repairs to the lock gates are necessary. A second dry dock is planned but is not to be built until necessary.

The average time for locking vessels through the three locks at Gatun is 65 min.; through the single lock at Pedro Miguel, 25 min.; and through the two locks at Miraflores, 45 min. Four towing locomotives are generally attached to the ships, though eight are used on the largest battleship. Tandem lockages with two ships in the same chamber at the same time have been made but are limited by the number of towing locomotives available. Parallel lockages are made only in emergencies.

The floating caisson was used for unwatering the lock at Miraflores to clean and paint the submerged machinery. Inspection revealed that galvanic action was taking place in the salt water between metals of different kinds. Tests are being made with preservative coatings having insulating properties which it is hoped will stop the corrosion. The rising stem valves were coated with bitumastic enamel, and a contract was made with the American Bitumastic Enamel Co. to paint all the submerged parts of the lock-gate structures and maintain them in first-class condition under a five-year guarantee.

A Big Blunder as to Vessel Measurement

After the canal had been in operation for some months, protest was made that the rules for vessel measurement adopted by presidential proclamation were not in accordance with the law and demand was made that the tolls collected in excess of legal authority should be refunded. The entire blame for this unfortunate situation is laid by General Goethals on Dr. Emory R. Johnson. Doctor Johnson was specially employed to draft the rules for Panama Canal measurement and to keep in touch with the legislative committees, which framed the law. The rules he drafted were supposed to conform strictly to the law as enacted. It later developed, however, that these rules have no legal standing and that, according to the letter of the law as enacted, the net registered tonnage of the vessel must apply. General Goethals says:

> Much to our chagrin and humiliation we learned that Dr. Johnson was aware of the discrepancy, notwithstanding which he presented his rules of measurement and rates of tolls for promulgation to the shipping interests of the world. Confusion has been the order of the day in consequence.

The greatest difficulty is not the refund of an illegal charge, but that, according to the law as it now stands, vessels must be assessed on their net registered tonnage, which may be varied by rulings and decisions of the Commissioner of Navigation. These rules as now applied cause discrimination in some cases against American ships in favor of foreign ships. It is roughly estimated that the total refunds necessary will amount to $400,000. These refunds cannot be made, however, notwithstanding the fact that the money was illegally collected, until Congress makes an appropriation authorizing them.

The total cost of operation and maintenance of the canal during the year was $4,112,000, while the tolls collected amounted to $4,343,000. When the above refunds are made, the operating expenses will exceed the toll receipts.

A Lighthouse on Navassa Island is under construction by the United States Bureau of Lighthouses. The island is an isolated rock with sheer cliffs about 200 ft. high, lying between Cuba and Hayti and in the track of vessels sailing between North Atlantic ports and the Panama Canal. A round tower 150 ft. high, of reinforced concrete, is being built on top of the rock, bringing the focal plane of the lens 402 ft. above water level. The light will have 56,000 cp., giving a double white flash every 30 sec. It will be visible for 27 nautical miles.

Eye-Bar Failure at Low Stress Causes Bridge Collapse

SYNOPSIS—Collapse of a steel bridge in Spokane, Wash., by the breaking of two lower-chord eye-bars has been investigated by a board of four local engineers and is charged to "granulation" of the metal. The stress in the metal is estimated at about 7,800 lb. per sq.in. Hugh L. Cooper, who designed the bridge, states that the bars were bent in an accident in 1894 and were straightened by local heating.

Breaking of the eye-bar bottom chord caused the collapse of the steel-truss main span of the Division St. bridge in Spokane, Wash., on Dec. 18, and dropped a street car into the Spokane River. Five men were drowned. Another car was left hanging by one truck on a pier. The fractures of the eye-bars were found to be crystalline.

The bridge has a 60-ft. south span and a 180-ft. main span, with trestle to the north. The main span was built in 1892 by the San Francisco Bridge Co.; Hugh L. Cooper, then District Engineer for the company, designed and erected the bridge. It was fabricated by the Edge Moor Bridge Works.

Data of the Span and Its Failure

The 180-ft. span was a through-truss structure of 8 22½-ft. panels, with curved top chords. It had a 40-ft. roadway and two sidewalks about 10 ft. wide. It was designed to carry a live-load of 4,800 lb. per lin.ft. This heavy loading made an unusually strong bridge, probably more than strong enough to carry present-day street cars without exceeding the original unit stress (15,000 lb.). The dead-load (originally about 2,600 lb. per lin. ft.) has been increased somewhat in recent years by added piping and by changes in the floor, probably 10 to 15%. This extra load is not significant. The details of the span were well ahead of contemporary practice. The floor-beams were riveted to posts and hangers.

The point of failure was the north end panel of the lower chord of the east truss, a member consisting of two 5x1½-in. eye-bars. Both bars broke near midlength, with clean square breaks. The bridge turned over in upstream direction and fell into 20 ft. of water. The piers (individual pedestals) were not damaged, though the shoes kicked off.

Board of Engineers Finds "Granulation"

A board of local engineers investigated the wreck at the request of City Engineer Morton Macartney and D. L. Huntington of the Washington Water Power Co. (operating the street railway).

The board, composed of S. H. Hedges, Bertram D. Dean, Frank M. Cortelyou and F. W. Crocker, reported as follows:

At your request the undersigned have today made a preliminary investigation of the failure of the Division St. bridge.

We examined at the city hall sections from two eye-bars which came from the end panel of the north end and east side of the bridge. We were also shown the original strain and section sheet from which this structure was built. We then went to the site of the bridge and investigated the structure as it now lies, partly in the water and partly on the bank. From all the above we unanimously arrived at the following conclusions:

It is our opinion that the failure was due to the simultaneous breaking of the bottom chord bars of the first panel of the north end of the east truss because of granulation.

There was no excessive load on the bridge at the time it collapsed, and in our opinion it is unlikely that there has ever been put upon this bridge a total load, including wood-block pavement, water pipes, street cars and other traffic, in excess of that for which the structure was designed.

We are reliably informed that the bridge was designed by Hugh L. Cooper, one of the foremost consulting engineers of the United States, and that the same was fabricated by the Edge Moor Bridge Works, one of the best bridge companies in the country.

We noticed breaks in the steelwork other than the ones above mentioned, caused by the falling of the bridge, and these show silky fractures indicating first-class material, and we are of the opinion that had this structure been carefully examined by experts the day before its failure they would have reported the same entirely safe for the duty it was fulfilling, and that there was no reason to expect defects of any character.

Prior Injury of the Chord Bars

An important piece of information is added by Hugh L. Cooper, the designer of the bridge. He says that the chord bars which broke were injured in 1894 and later were repaired in a way that probably left them permanently weakened. Mr. Cooper made the following statement to *Engineering News* of this phase of the matter:

I visited the scene of the wreck two days after it occurred. It is apparent that the cause of the wreck was the pulling apart of both of the bottom-chord eye-bars of the east truss in the panel next the abutment. These bars were 5x1½ in. in cross-section. The breaks are opposite one another and show the same general characteristics—a very clean break all the way across, practically no fibrous condition of the metal, the entire surface looking highly crystallized.

At the time of the accident it is probable that these bars were being stressed (if they were equally loaded) not to exceed 7,800 lb. per sq.in.

From the information I gathered in Spokane it is apparent that in 1894, at a time of unusual high water, a heavy Howe-truss railway bridge was washed from its foundations and floated downstream and struck the end bottom chords of this span a heavy blow, severely distorting both of the bars that broke. The Howe-truss span, after colliding with the upstream bars, was forced down into the water and came up with a new blow, striking the downstream chord bars opposite the bars that parted, breaking one of these bars entirely. My information is to the effect that when the city authorities came to repair the structure after this accident, the bar that broke entirely in two downstream was replaced by a new bar and the upstream bars were taken out and locally heated, straightened and reinserted in the structure.

My own thought of the explanation in the light of the information I have is that the blow received by the upstream bars was sufficient to stretch them beyond their elastic limit, and in addition the straightening by local heating without reannealing produced conditions that were also unsafe. The bars should never have been allowed to continue in service.

There is some conflict of opinion as to just what point in the upstream chord was first struck by the Howe truss.

One of the incidents confirming my personal view of the cause of the accident is found in the fact that the upstream chord bar of the two that broke shows a marked bruise that might have been caused by a screw end of one of the vertical rods in the Howe-truss span. This bruise is located within three inches of the break and is in the center of the bar.

City Engineer's Doubts Accident Theory

Doubt is thrown on the accident theory by Morton Macartney, city engineer, in the following interview, which appeared in the Spokane dailies:

City Bridge Foreman John McCormick, who then was in the employ of the city, tells me that it was another panel of

the bridge that was bent in the 1894 flood. He says the bent portion still shows. It is true that blows of a hammer showed on the part of the bridge that broke, a condition apparent after the paint was off, but how the blows came there is more than I can tell. So far I have found no city record telling that this member was bent and repaired at that time.

In rejoinder to this, Mr. Cooper reasserts his information that the eye-bars struck in the 1894 accident were the particular ones that broke in the present collapse.

A further fact possibly bearing on the accident is that at the fracture one bar showed a small flaw like a slag inclusion, making a slight indentation from one side face.

The American Bridge Co., successor of Edge Moor Bridge Works, has not been able to find a record of the character of the metal in the bridge. That the metal is steel is well established; a strength of 60,000 lb. per sq.in. was specified. The eye-bars were press-upset and were then annealed, according to the Edge Moor process, which has since come into general use.

Eye-bars for a railway bridge also designed by Mr. Cooper were made in the same shop at the time the Division St. eye-bars were made, and this bridge is still in service, not far from Spokane.

Garbage-Disposal Bids Invited by New York City

OFFICIAL STATEMENT

The existing contracts for the disposal of garbage, ashes and rubbish in New York City expire Jan. 1, 1917, though the city has the privilege of renewing these contracts for a further period of two years. For the purpose of determining the advisability of such renewal, new contracts will be advertised. Bids will be received Jan. 18, 1916, on two forms of contract for the disposal of garbage.

Form No. 1 provides for the disposal of garbage at private plants located on private lands for a period of five years. The feature of this contract requires the contractor to pay the city an amount per annum for the privilege of disposing of garbage. The total amount of garbage delivered in 1914 was 412,200 cartloads of 2 cu.yd. capacity, weighing approximately 2,330 lb. per cartload. Plans and specifications are to accompany the bid, showing the general outline of plant and methods of treatment proposed for use by the contractor. Stringent provisions cover design of plant and equipment so as to obviate nuisance due to the escape of odorous gases or other obnoxious wastes.

Form No. 2 differs from the preceding contract in that the plant will be erected on a site provided by the city. The contract term is limited by law to a period of five years, and the city agrees to purchase the plant on the termination of the contract, at a price to be fixed in the bid or estimate by the contractor. The contract likewise requires the bidders to submit general plans and a guaranteed maximum estimated cost for the construction of the plant and appurtenances. The methods proposed to be used and the design of apparatus are subject to approval by the Commissioner of Street Cleaning, and definite guarantees covering nuisances and odors are required, as in Form No. 1.

Under the conditions noted in Form No. 1 the contractor would naturally amortize his plant during the five-year term of contract, while in Form No. 2 the contractor finances the undertaking and is required to make any profits out of the operation of the plant during the term of the contract, as the plant is to be built at actual cost under the supervision of the city.

On account of the difficulty of securing city funds for the construction of a municipal plant at the present time, the authorities decided to attempt to interest private capital in financing the undertaking under Form No. 2, as there is but a slight risk in the investment on account of the city's agreement to purchase the plant, it would seem as if this would be the more attractive proposal to contractors.

Last year the Commissioner of Street Cleaning attempted to secure state legislation which would enable the city to make a 15-yr. profit-sharing contract for the disposal of all classes of wastes. The bill passed both houses of the legislature, but was vetoed by the governor. Thus the city has available only two means of disposing of its waste: First, by contract for a period not to exceed five years; and second, by municipal construction and operation of the disposal works.

J. T. Fetherston is Commissioner of Street Cleaning of New York City.

Locomotives for Railways of Sharp Curvature

Anatole Mallet, of Paris, France, the inventor of the Mallet articulated locomotive, was the author of a paper presented before the Railway Section of the American Society of Mechanical Engineers at the recent annual meeting giving a historical review of the numerous locomotives which have been designed to traverse lines of sharp curvature.

The best-known locomotives of this type in use in the United States are the geared locomotives of the Climax, Shay and Heisler systems. These are in extensive use on logging roads, where steep grades and sharp curvature are generally essential to economical construction. Some other locomotives of this type which have been built in the United States are the Cowles locomotive, described in *Engineering News* of Feb. 9, 1893, and the Johnstone locomotive, designed by a former superintendent of motive power of one of the Mexican railways and adopted on several locomotives built in the United States for service there.

The interest in this problem was much greater in the early days of the railway era, when it was supposed to be difficult or impossible to run a locomotive with several coupled pairs of drivers around any but the easiest curves. There is, however, at the present time, constant pressure on the railway mechanical departments to build as heavy locomotives with as many coupled drivers as can possibly be gotten over the track, and there is no doubt that a considerable outlay for track repairs is made necessary by the action on curves of heavy locomotives of long wheel base.

In the discussion upon Mr. Mallet's paper, Mr. Woodward, assistant chief engineer of the American Locomotive Co., stated that his company has recently built a new type of locomotive in which provision is made for lateral movement in the end driving axles (the locomotive is of the 2-10-2 class), to enable it to pass freely around sharp curves without cramping. The locomotive has a rigid wheel base 22 ft. 6 in. long, yet it has been run around yard curves of 20° without injury to the track.

News of the Engineering World

Chattanooga Bridge Falsework Swept Away by Flood

Unexpected high water in the Tennessee River caused the loss of one coffer-dam and the centering of one of the arches of the Market St. bridge now under construction at Chattanooga, Tenn., on Dec. 20. The bridge is a series of reinforced-concrete arches, 165 ft. and 180 ft. in span, with a middle double-leaf bascule span of 300 ft. On the Chattanooga side of the river, arches 1 and 2 were practically completed and the centering under arch 3 (180-ft. span) had just been placed, together with most of the reinforcement for the arch ring. Pier 4 (piers 3 and 4 are the bascule piers) was under construction inside of a steel sheet-pile coffer-dam.

The centering and falsework for arch 3 were completed Dec. 18, and it was planned to start pouring the next day. At that time the river was at a 17-ft. stage; but the Weather Bureau sent in word that a flood stage was due, and the entire bridge force was put to work cleaning out the driftwood. Late Saturday night, however, a large tree broke through the pile footings of the centering. With a pressure of the driftwood 100 ft. behind it the falsework, which had already buckled and cracked, collapsed on Sunday morning at a 29-ft. stage. Immediately afteward a tug was sent after it and captured the débris 10 mi. down the river and tied it to the bank. It is believed that $1,000 worth of steel can be salvaged.

In addition to the loss of the centering the coffer-dam for pier 4 was washed out earlier in the day. This is the third time that this coffer-dam has been lost.

The bridge is being built by the Vang Construction Co., of Cumberland, Md., for the Tennessee River Bridge Commission. It was designed by B. H. Davis, of New York. Ellis Soper is construction engineer.

The foundation work for the bridge has been troublesome from the beginning. Preliminary borings placed the rock bottom too high, and the originally intended open coffer-dam method has had to be replaced by pneumatic caissons in two of the piers.

One Span of Memphis Bridge Falsework Washed Out

A part of the falsework of the new cantilever bridge across the Mississippi River near Memphis, Tenn., was washed out in the high water of Dec. 23, 1915. At the request of *Engineering News* the following statement was made by Thomas Earle, Superintendent of the Bridge and Construction Department of the Pennsylvania Steel Co., which is fabricating and erecting the bridge:

"On the night of Dec. 23, 1915, fifteen bents of the falsework which had been placed in the Mississippi River for the erection of the bridge of the Arkansas & Memphis Railway Bridge and Terminal Co., near Memphis, Tenn., were washed out by high water. These bents were to have supported the semisuspended span between piers 3 and 4. The falsework consisted on an average of 32 piles per bent, the piles ranging from 84 to 94 ft. in length. On these piles rested the timber falsework, consisting of 12x12-in. legs about 65 ft. high. The river was at a height of 28 ft. at the time of the washout and full of heavy drift.

"In addition to the falsework a small amount of erection equipment was lost, including some stringers of the permanent construction which were being used temporarily in the falsework. No other permanent steel was lost.

"The bridge is to carry railway and highway traffic, and starting at the Memphis side will consist of the following spans (see *Engineering News*, Nov. 6, 1913, p. 930): East abutment to pier 1, anchor arm, 186 ft. 3¾ in.; pier 1 to pier 2, 790-ft. 5¼-in. span comprising a cantilever arm of 186 ft. 3¾ in., a suspended span of 417 ft. 9¾ in. and a cantilever arm of 186 ft. 3¾ in.; pier 2 to pier 3, fixed span, 621 ft. long; pier 3 to pier 4, a 604-ft. 1½-in. span comprising a cantilever arm of 186 ft. 3¾ in. and a semisuspended span of 417 ft. 9¾ in.; pier 4 to pier 5, deck span, 345 ft."

Subsequent to the receipt of the foregoing, the following local report of the collapse was received:

"Following an unusual rise in the Mississippi River to about 27 ft. on the Memphis gage, and the piling of drift against it, 14 bents of falsework between piers 3 and 4 of the new Memphis bridge went out at 11:30 p.m., Dec. 23, leaving five bents next to pier 3 standing. On Saturday, Dec. 25, about 3:30 a.m., the fifth bent west of pier 3 went out. A small gantry traveler, the falsework derrick and four hoisting engines with their rigging went with the falsework, as did 120 roadway stringers being used as stringers for the traveler tracks. The remaining bents of this span carry the bottom chord and floor system of the cantilever arm, leaving two panels of bottom chord projecting. Bolts at the splice at panel-point 12 were removed, so if the remaining bents go out, it is expected the break in the steel will occur at this point and not greatly damage the end of the fixed span at pier 3.

"All pins in span 2-3 (621 ft. fixed span) were in by 2 p.m., Dec. 22, and the remaining portal bracing and top laterals by noon the next day. Lowering of this span was begun at once and proceeded until dark under extra force; very little weight then remained on the falsework. All joints are closed and well bolted, and it is believed this span will hold even though the falsework under it goes out. The drift piled up for a distance of about 60 ft. upstream in spite of all attempts to prevent it. The falsework for span 3-4 was in 60 ft. of water at the time of failure, with 30-ft. penetration, while that of span 2-3 was in 75 ft. of water with 35-ft. penetration.

"The river stage at 7 a.m., Dec. 28, is about 31 ft. A stage of 32 ft. is expected."

The Memphis bridge was designed by Ralph Modjeski, of the firm of Modjeski & Angier, Chicago, and is being erected under his supervision.

FIG. 1. LOOKING SOUTH; EXCAVATION FOR PINE HILL CONCRETE DAM

Showing progress of work on the construction of a $700,000 reservoir, using entirely municipal day labor and municipally owned equipment. Text describing the work on opposite page

FIG. 2. LOOKING NORTH; EXCAVATION FOR PINE HILL DAM, WORCESTER, MASS.

Excavation to bedrock is completed in the foreground. The distance across is about 850 ft. All rock excavation was done with small compressed-air hand drills

Pine Hill Dam for Worcester Additional Water-Supply

The city of Worcester, Mass., has had under construction for over a year a cyclopean masonry dam, which will rank among the largest in New England. Construction work is proceeding rather slowly because the city is doing all operations by municipal labor and with small annual appropriations; no construction contracts have been, nor are to be, let. This alone will make the work of much interest to municipal engineers. The estimated cost is about $700,000.

The dam is near the present Holden reservoirs of the city water-supply. It will be 108 ft. high from foundation to top, 80 ft. wide at the base and 17 ft. wide at the top. The top is 850 ft. long. It dams the narrow outlet of a natural basin of rather remarkable topography.

Solid rock underlies the whole dam site. The top strata of soil, soft and disintegrated rock are excavated by derrick skips and conveyed by narrow-gage railways to a temporary spoil bank. The material will be used to grade below the completed dam. Rock excavation is accomplished by two Jackhamer compressed-air drills. A small WK-3 gasoline-engine-driven Sullivan compressor of 20 hp. is used to supply air. Large pieces of rock are piled within reach of the derrick booms to be used later as "plums" in the dam masonry. Steam tripod drills are used to make test holes; some of these are 50 ft. deep.

Rock excavated near the dam site will be used for concrete aggregates. There is no sand within reasonable distance, so a pair of 14x20-in. sand rolls have been installed, and the rock will be used to make sand as well as the coarser concrete aggregate. All the material is handled by derricks, a cableway and narrow-gage railways.

Concrete is to be mixed with a Hains gravity mixer. The sand and stone bins and the cement house are at the north end of the dam. Narrow-gage railway cars will carry these materials to a chute, which will convey them to the hopper platform of the concrete mixer.

All the plant and equipment have been purchased by the city and erected by day labor under the supervision of the City Engineer, F. A. McClure. The city has even gone so far as to build its own railway cars and derricks. At the opening of another season Mr. McClure expects to have 250 men employed. As yet the excavation has not been completed.

Terre Haute Water Rates Cut

The meter rates of the Terre Haute Water Co. have been ordered reduced to the advantage of small consumers, the cost of service connections has been put upon the company, the fire-hydrant rate has been confirmed, but the company is not compelled to install so many hydrants on extensions as heretofore. These and other rulings are embodied in an order of the Indiana Public Service Commission, dated Dec. 18, 1915, as a result of a petition filed Oct. 16, 1913, by the Commercial Club of Terre Haute.

The meter rates are on a sliding scale. For the first 20,000 gal. a month the new rate will be 20c. instead of 30c. per 1,000 gal. For successive additional quantities the rate falls until for all consumption of more than 3,000,000 gal. a month the unit rate is 4¼c.—a slight increase, as the old rate was 4½c. The minimum monthly charge for metered water is $0.60 for ⅝- and ¾-in. meters, $1 for 1-in., on up to $20 for 6-in. and over.

The minimum charge per month for private fire protection is 50% above the charges just given. All private fire-protection services must be metered.

The flat rate is $5 per kitchen faucet for a private family living in six rooms or less, where there is not more than one room rented nor more than two boarders. Additional charges are $3 each for a bath and water closet, $3.50 for one horse and $6 for sprinkling a 50-ft. lot.

The old fire-hydrant rental of $40 each per year stands, but the company need set only one hydrant per 500 ft. of extensions instead of one for each 355 ft. under the old rates.

The value of the property of the company is fixed by the commission at $1,200,000, including $80,000 for going value. The company may earn 6½% on this valuation after allowing for maintenance, operation and 0.83% for depreciation.

The commission ordered the company to pay the state $1,386 for the expense of the rate adjustment and cut from $12,500 to $9,000 the sum the company wished to charge to current expenses on account of the valuation proceedings, holding that the $3,500 must come out of dividends.

Dow R. Gwinn, President of the Terre Haute Water Co., is given credit for getting remarkably good results from a filtration plant now out of date. On this subject the commission says, "We believe the most valuable part of the filtration system is the gray matter of the president of the water company."

New Rules of Practice of the United States Patent Office have been approved by the Secretary of the Interior and are to take effect on Jan. 1. The new rules have been framed by a committee of which R. F. Whitehead, Assistant Commissioner of Patents, is chairman, and before final adoption were submitted for criticism to patent experts and patent attorneys throughout the country.

The Alaskan Engineering Commission, in charge of the construction of the Government railway in Alaska, received over 38,000 applications for positions before it left for Alaska last spring, according to a statement by Secretary Lane in his annual report. Most of those applying for positions, however, were not men out of work, but were men holding positions with railway companies, banks, stores, etc.

Derailment Wrecked Bridge—The steel span of a bridge of the Nashville, Chattanooga & St. Louis Ry., about 25 mi west of Nashville, was destroyed on Dec. 13, when part of a freight train was derailed. The derailment was followed by the ignition of the contents of an oil-tank car, and four tank cars and nine cars of merchandise burned. The span was 96 ft. long and was single-track. A trestle approach on concrete bents was burned completely, with no damage to the bents, the repair crew being able to replace the wooden stringers immediately. The bridge was replaced by a temporary structure in four days, but after one train had run over it three bents were carried away by high water. New bents were erected immediately, and traffic was resumed in a few hours. It is expected that a new steel bridge will be in place permanently by Jan. 1.

The Street Railways of Melbourne, Australia, are operated by the Melbourne Tramway and Omnibus Co., whose franchise expires on July 1, 1916. The railways were built about 30 years ago under a coöperative agreement between the city and the railway company. The city furnished the capital for building the lines (about $8,000,000), and the company furnished the rolling stock, car barns and general offices. The company has paid an annual rental to the city of about $200,000 per annum. The city has planned to take over the lines for municipal operation at the expiration of the franchise, but the Provincial Government has introduced a bill under which it would control and operate the line in connection with a plan for a greater Melbourne consolidation.

The lines are still operated by cable traction, and their rebuilding is likely to be undertaken when the question of control at the expiration of the franchise is settled.

PERSONALS

Prof. Arlo Bates, Professor of English in the Massachusetts Institute of Technology, has retired, under the pension system of the Carnegie Foundation, after 22 yr. of service.

Mr. J. W. Frazier, who has been a draftsman in District No. 4 of the Pennsylvania State Highway Department, has been promoted to the superintendency of highways of Potter County.

Mr. C. H. Orndorf, draftsman attached to District No. 2 of the Pennsylvania State Highway Department, at Harrisburg, has been promoted to be Superintendent of Highways of Clinton County.

Mr. H. S. Wood, Chief of Construction in District No. 15 of the Pennsylvania State Highway Department, has been promoted to be Superintendent of Highways of McKean County, with headquarters at Warren.

Prof. Harold A. Everett, of the Department of Naval Architecture of the Massachusetts Institute of Technology, has resigned to take a position in the Post Graduate School of the United States Naval Academy at Annapolis.

Mr. Henry C. Beckwith, M. Am. Soc. M. E., formerly Chicago Manager of the T. L. Smith Co., is now Treasurer and General Manager of the Byers Machine Co., manufacturers of hoisting and excavating machinery at Ravenna, Ohio.

Mr. William B. Goentner, former Assistant Engineer of the New York City Department of Water-Supply, Gas and Electricity in charge of design of distribution systems, is now Superintendent of the McCabe Chemical Co., Charlotte, N. C.

Mr. W. S. Hanmaker, County Superintendent of Highways of Cumberland County, has been promoted to be Acting Assistant Engineer in charge of District No. 9 of the Pennsylvania State Highway Department, with headquarters at Chambersburg.

Mr. D. A. McCloskey, Acting Chief of Construction of District No. 11 of the Pennsylvania State Highway Department, has been promoted to be Superintendent of Highways of Huntingdon County, taking the place of T. J. Strickler, who recently resigned.

Mr. F. E. Winter, Resident Engineer in charge of inspection at Warren, of the Pennsylvania State Highway Department, has been promoted to the post of Acting Assistant Engineer in the newly created District No. 8, including Clearfield, Indiana, Jefferson, Elk and Cameron counties.

Mr. E. R. Lewis, M. Am. Soc. C. E., Assistant to the General Manager of the Duluth, South Shore & Atlantic Ry. Co., with office at Duluth, Minn., will after Jan. 1 have charge of all matters pertaining to engineering, maintenance of way and structures and federal valuation of the company.

Mr. W. R. Wolfinger, who has been Assistant Engineer in charge of District No. 9 of the Pennsylvania State Highway Department, at Chambersburg, has been transferred to District No. 5, with headquarters at Allentown. He succeeds John T. Gephart, Jr., who will return to Harrisburg and resume his duties as Engineer of Construction.

Maj. R. E. Wood, Chief Quartermaster at Panama and Director of the Panama R.R., has joined the staff of the Barber Asphalt Paving Co. as Assistant to the President, with headquarters at Philadelphia. Major Wood graduated from West Point to 1900, was connected with the building of the canal from 1905 to 1915 and retired with the rank of major under the Panama Canal Act.

Mr. William E. Davis, Vice-President of the Cleveland Construction Co., has been appointed Public Utilities Engineer of Cleveland, Ohio, at an annual salary of $7,000. Mr. Davis will fill the combined positions now held by Lighting Commissioner F. W. Ballard, Assoc. Am. Inst. E. E., and Water Commissioner Charles F. Schulz. Commissioner Ballard receives $7,000, and Commissioner Schulz $5,000 a year.

Prof. William D. Pence, M. Am. Soc. C. E., has decided to sever his connection as Professor of Railway Engineering at the University of Wisconsin. He will be succeeded by Prof. L. F. Van Hagan, Assoc. M. Am. Soc. C. E., who has been promoted to the position of Associate Professor and placed in charge of the department. Professor Pence has been a member of the Interstate Commerce Commission Railway Valuation Board since its inception.

Mr. Gustav J. Requardt, Assoc. M. Am. Soc. C. E., will leave the employ of the Baltimore Sewerage Commission, Jan. 1. Mr. Requardt has been with the commission since 1909, when he was a rodman on the location of structures at the sewage-disposal plant; since then he has been Assistant Engineer on the design of sewer and drains through the city, Assistant Division Engineer in charge of design and construction of new filters and Imhoff tanks and for the last year has been acting as Division Engineer in charge of operation and construction at the disposal plant. He expects to go into the private practice of civil and sanitary engineering.

Mr. A. K. Silvernail has been elected President of the newly organized Kimberly Construction Co., Mayro Building, Utica, N. Y. Mr. Silvernail is a graduate in civil engineering of the Carnegie Institute of Technology. Subsequent to his graduation he was engaged in the construction department of the New York Central and Lehigh Valley railroads and was in charge of construction of a large department-store building in Corpus Christi, Tex. In 1912 he went to Utica and has since that time had charge of the contruction of many of the public building in that city. He is at present Supervising Engineer on the Utica Homeopathic Hospital Building.

Mr. William F. Kelly and Mr. Charles B. Cooke, Jr., have formed a partnership with the firm name of Kelly, Cooke & Co., with offices in the Drexel Building, Philadelphia, Penn., to conduct a general practice in public-utility and industrial engineering. Mr. Kelly was for several years connected with the engineering staff of the Union Traction Co., of Philadelphia, and for the past 14 yr. has been a member of the staff of Ford, Bacon & Davis, acting as engineer in charge of several of their larger operations, including the construction and reconstruction of the Knoxville Railway and Light Co. and the Birmingham Railway, Light and Power Co. Mr. Cooke was formerly Assistant Commercial Engineer of the Westinghouse Machine Co., at East Pittsburgh, and for several years past has been on the staff of Ford, Bacon & Davis, during which time he specialized on financial engineering reports and had personal charge of a number of important rate developments and reports for public-utility companies. Both members of the firm are graduates of the University of Pennsylvania.

OBITUARY

Francis Winthrop Scarborough, M. Am. Soc. C. E., Consulting Engineer of Richmond, Va., died in New York City Dec. 24.

Henry Wick, Assoc. Am. Soc. M. E., President of the Elyria Iron and Steel Co., died at Youngstown, Ohio, Dec. 22. He was born in that city in 1846 and had been active for nearly 50 yr. in the iron and steel trade in Ohio. He was formerly President of the Ohio Steel Co. and the early Youngstown Rolling Mill Co.

George V. Sneden, Superintendent of Maintenance-of-Way of the New York & Long Branch R.R., and the oldest employee of the company in point of service, died at his home in Red Bank, N. J., Dec. 24. He was born in Fredericksburg, Va., in 1856 and studied civil engineering at Lehigh University. In 1874 he became a member of the engineering corps engaged in the construction of the road.

William Wilson Ramsey, of the Ramsey Engineering Co., Chicago, died at his home in that city Dec. 3. He was born in Chester County, Pennsylvania, and went to Chicago in 1876. He was formerly Manager of the Northwestern Expanded Metal Co., and was largely influential in promoting the present extensive use of metal lath. About 1893, when reinforced concrete began to be used for building construction, Mr. Ramsey organized the Expanded Metal Fireproofing Co., and since that time he had been actively connected with the design and construction of concrete for structural work.

William Weeden Cole, M. Am. Soc. C. E., Consulting Engineer, New York City, was found dead, Dec. 20, in a hotel in Poughkeepsie, N. Y., to which city he had gone on business. It is thought that he was accidentally asphyxiated. He was born at Medford, Mass., in 1868. At various times he was Division Engineer of the Toledo, St. Louis & Kansas City Ry., Superintendent of Electrical Affairs on the West End Street R.R., in Boston, and was identified with the Utica (N. Y.) Belt Line, designing and building the West Side R.R. and Elmira Heights Water-Works. For a period of 16 years he was associated with the Public Utilities Co., of Elmira, during which time the city's gas, electricity, street

railways and water were consolidated into one corporation, of which he was the Vice-President and General Manager. In 1907 Mr. Cole left Elmira to enter the firm of Day & Zimmerman, of Philadelphia, where he remained for seven years, after which he became a member of the firm of Cole, Ives & Davidson, of New York City.

ENGINEERING SOCIETIES

COMING MEETINGS

SECOND PAN-AMERICAN SCIENTIFIC CONGRESS.
Dec. 27-Jan. 8. Washington, D. C.

AMERICAN CIVIC ASSOCIATION.
Dec. 28-31. Annual convention in Washington, D. C. Secy., R. B. Watrous, Union Trust Bldg., Washington, D. C.

SOCIETY OF CONSTRUCTORS OF FEDERAL BUILDINGS.
Jan. 3-6. Seventh annual convention in Washington, D. C. Secy., C. R. Marsh, Brattleboro, Vt.

ALABAMA ASSOCIATION OF HIGHWAY ENGINEERS.
Jan. 8. Annual meeting in Montgomery. Secy., J. B. Converse, City Engineer, Selma, Ala.

LOUSIANA ENGINEERING SOCIETY.
Jan. 8. Annual meeting in New Orleans. Secy., W. T. Hogg, State Museum Bldg., New Orleans, La.

WESTERN SOCIETY OF ENGINEERS.
Jan. 12. Annual meeting in Chicago. Acting Secy., E. N. Layfield, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF PENNSYLVANIA.
Jan. 14. Annual meeting in Harrisburg. Secy., E. R. Dasher, 30 So. Front St., Harrisburg, Penn.

CENTRAL RAILWAY CLUB.
Jan. 14. Annual meeeting in Buffalo, N. Y. Secy., H. D. Vought, 95 Liberty St., New York City.

WESTERN PAVING BRICK MANUFACTURERS' ASSOCIATION.
Jan. 14-15. Annual meeting in Kansas City, Mo. Secy., G. W. Thurston, 416 Dwight Bldg., Kansas City, Mo.

MONTANA INSTITUTE OF MUNICIPAL ENGINEERS.
Jan. 17-19. Annual meeting at Billings, Mont. Secy., C. C. Widener, Bozeman, Mont.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 19-20. Annual meeting in New York City. Secy., C. W. Hunt.

NATIONAL DRAINAGE CONGRESS.
Jan. 19-21. Annual meeting, Cairo, Ill. Vice-Pres., Edmund T. Perkins, First National Bank Building, Chicago, Ill.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Jan. 20-22. Annual convention in Minneapolis. Secy., Alvin E. Dodd, 140 West 42nd St., New York City.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.
Jan. 18. Annual meeting in Pittsburgh. Secy., E. K. Hiles, 2511 Oliver Building, Pittsburgh, Penn.

KANSAS ENGINEERING SOCIETY.
Jan. 18-19. Annual meeting at Kansas State Agricultural College. Secy., C. A. Foster, Topeka, Kan.

AMERICAN WOOD-PRESERVERS' ASSOCIATION.
Jan. 18-20. Annual convention in Chicago. Secy., F. J. Angier, Mount Royal Station, Baltimore, Md.

THE FRANKLIN INSTITUTE.
Jan. 19. Annual meeting in Philadelphia. Secy., R. B. Owens, Philadelphia, Penn.

ILLINOIS CHAPTER: AMERICAN WATER-WORKS ASSOCIATION.
Jan. 25-27. Annual meeting, University of Illinois, Urbana. Secy., Dr. Edward Bartow, Urbana, Ill.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 26-28. Annual meeting, University of Illinois, Urbana, Ill. Secy., E. E. R. Tratman, Wheaton, Ill.

WISCONSIN HIGHWAY COMMISSIONERS' ASSOCIATION.
Jan. 31. Annual meeting in Madison. Secy., G. H. Mainwaring, Gotham, Wis.

INDIANA SANITARY AND WATER-SUPPLY ASSOCIATION.
Feb. 2-5. Annual meeting in Indianapolis. Asst. Secy., W. F. King, Indianapolis, Ind.

INDIANA ENGINEERING SOCIETY.
Feb. 3-5. Annual meeting in Indianapolis. Secy., Charles Brossmann, 1616 Merchants Bank Bldg., Indianapolis, Ind.

NINTH CHICAGO CEMENT SHOW.
Feb. 12-19. First Infantry Armory and Coliseum. Secy., R. F. Hall, 208 South La Salle St., Chicago, Ill.

AMERICAN CONCRETE INSTITUTE.
Feb. 14-17. Annual convention in Chicago. Secy., John M. Goodell, 1418 Walnut St., Philadelphia, Penn.

ASSOCIATION OF ONTARIO LAND SURVEYORS.
Feb. 15. Annual meeting in Toronto, Can. Secy., L. V. Rorke, Parliament Building, Toronto, Ont.

SECOND NATIONAL CONFERENCE ON CONCRETE ROAD BUILDING.
Feb. 15-18. At Chicago. Secy., J. P. Beck, 208 South La Salle St., Chicago, Ill.

IOWA ENGINEERING SOCIETY.
Feb. 16-18. Annual meeting at Des Moines. Secy., J. H. Dunlap, Iowa City, Iowa.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.
Feb. 16. Annual meeting in Boston. Secy., N. W. Gifford, 38 Central Sq., East Boston, Mass.

AMERICAN CONCRETE PIPE ASSOCIATION.
Feb. 17-18. Annual convention in Chicago. Secy., E. S. Hanson, 538 South Clark St., Chicago, Ill.

AMERICAN ROAD BUILDERS' ASSOCIATION.
Feb. 22-25. Annual convention in Pittsburgh. Secy., E. L. Powers, 150 Nassau St., New York City.

The Pacific Northwest Society of Engineers will hold its annual meeting and year-end dinner in Seattle, at the Arctic Club, on Jan. 8.

The Ohio Engineering Society will hold its 38th annual meeting in Columbus, Feb. 9 to 11. The secretary is John Laylin, Norwalk, Ohio.

Iowa Engineering Society—The annual meeting will be held at Des Moines, Feb. 16 to 18. The secretary is J. H. Dunlap, Iowa City, Iowa.

American Electric Railway Association—The annual midwinter meeting will be held at the Congress Hotel, Chicago, Feb. 4, 1916. The general discussions will center around the topics "Valuation" and "Rate of Return."

The Cleveland Association of Members of the American Society of Civil Engineers has elected the following officers for 1916: President, Robert Hoffmann; vice-president, W. J. Watson; secretary-treasurer, Geo. H. Tinker. The new president is chief engineer of the Department of Public Service of Cleveland.

The Engineers' Society of Pennsylvania at its December meeting elected the following officers: President, R. Boone Abbott, division engineer, Philadelphia & Reading Ry.: first vice-president, W. W. Davis; second vice-president, Morris Knowles; directors, F. A. Robbins, Jr., D. E. Tracy, Elton D. Walker; treasurer, John O'Connell; secretary, Edward R. Dasher, 31 So. Front St., Harrisburg, Penn.

Buffalo Engineering Society—At a meeting on Dec. 15 the relation of the engineer to civic welfare and the municipality was discussed by C. E. Drayer, secretary of the Cleveland Engineering Society. He urged that local engineering societies should aid municipal governments in the proper solution of engineering problems. Three of the councilmen-elect, who are to conduct the commission government of Buffalo after Jan. 1, were present at the meeting. A resolution was adopted to appoint a committee of five to coöperate with the municipal commission in the solution of engineering problems. John Younger, Chief Engineer of the truck-department of the Pierce-Arrow Motor Car Co., said that his company was willing to coöperate with the schools of the city in the training of students in mechanical trades according to the coöperative educational plan.

The San Francisco Association of members of the American Society of Civil Engineers held its eleventh annual meeting at the Palace Hotel on Dec. 17. Vice-president Couchot presided, and 49 members and guests were present. A communication from Jerome Newman, suggesting that an effort be made to ascertain the views of the association as to the extent to which it is justifiable for one engineer to use the plans and specifications of another without permission and without giving credit to the latter, was read. After a brief discussion by Messrs. Newman, Marx, Brunnier, Rhodin and Duryea it was ordered that a committee of five be appointed to define principles of ethics in engineering practice and report at a subsequent meeting. Officers for the ensuing year are: President, H. L. Hachl; vice-president, Jerome Newman.

The Engineering Association of the South held its annual meeting in Nashville, Tenn., at the Commercial Club, on Dec. 18. The election of officers was announced as follows: President, T. P. Branch, Professor of Civil Engineering of the Georgia School of Technology, Atlanta, Ga.; vice-presidents, John Howe Peyton and L. M. Thacher; secretary, J. Harwell Allen, of the Allen-Scales Engineering Co., Nashville, Tenn.; directors, C. S. Brown, C. H. Simpson and L. J. Hill. Professor Brown, the retiring president, read a paper on smoke abatement. James Cameron, of New York City, who is conducting the municipal audit at Nashville, called attention to a defect in the present city charter. The commissioners can issue bonds for trunk sewers, but to do the same thing for laterals is illegal. A committee was appointed by the association to devise a remedy.

Associated Engineering Societies is the name under which the following engineering organizations have combined: Pacific Northwest Society of Engineers, Washington Association of Engineers, local sections of the American Society of Civil Engineers, American Institute of Electrical Engineers, American Institute of Mining Engineers, American Chemical Society. A joint council consisting of two members from each of these societies will work out a scheme of operation for

1916. The Engineers' Club is considering the question of joining the association as a charter member, and an invitation has been extended to the Washington Chapter of the American Institute of Architects. The members of the preliminary joint council are: J. T. Dovey, S. H. Hill, S. C. Lindsay, E. A. Loew, G. A. Collins, Amos Slater, C. E. Magnusson, G. P. James, J. H. Linton, C. A. Newhall, J. L. Hall and Robert Howes.

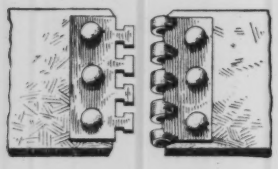
American Road Builders' Association—A special meeting of the board of directors was held in New York on Dec. 16, at which it was decided to hold the convention for 1916 in Pittsburgh, beginning on Feb. 28. The board also adopted a resolution inviting the American Highway Association to hold its annual convention for 1916 at Pittsburgh at the same time. In case the invitation is accepted by the American Highway Association, a committee of the American Road Builders' Association will be authorized to join with representatives of the other association in the preparation of a program for the two meetings, which will avoid the duplication of subjects. The resolution further recited that it was the hope of the directors of the American Boad Builders' Association that some such plan as outlined may be found satisfactory not only for 1916 but for subsequent meetings which may be held under alternate control.

The Minnesota Joint Engineering Board was organized at an informal meeting held recently at the St. Paul Commercial Club. The meeting was called by the president of the Minnesota Section of the American Institute of Electrical Engineeers, and the president or chairman of each of the following engineering organizations was present: Minnesota Section of the American Society of Mechanical Engineers, Northwest Association of the Members of the American Society of Civil Engineers, Minnesota Surveyors' and Engineers' Society, Minneapolis Engineers' Club, Civil Engineers' Society of St. Paul. The dean of the College of Engineering of the University of Minnesota also attended. After general discussion as to how to make the board of greatest value to the engineering profession the meeting was adjourned. It will meet for luncheon at the Minneapolis Club on Jan. 4, at which time it is hoped that the work of organization will be completed.

Appliances and Materials

New Belt Coupling

A new belt coupling, of particular interest to contractors because of the ease of opening the joint, has been brought out by Stewart & Co., 171 Broadway, New York City. As shown in the acompanying sketch, there are two plates riveted to the two ends of the belt (with clinch rivets). From one plate extend a series of eyes engaging the pins of the other plate when the joint is closed. This form of coupling costs complete from 90c. per doz. for 1-in. belts to $2.50 per doz. for the 6-in. size.



STEWART BELT JOINT

* * *

New Glass for Industrial Apparatus

A new borosilicate glass, combining very low thermal expansion with great resistance to attack of chemical reagents, has been developed at the Corning Glass Works, Corning, N. Y. Its specific gravity is 2.25; the mean linear expansion coefficient (19° to 350° C.) is 0.0000032. Water at boiling temperature dissolves an amount of this glass several times less than of the best imported laboratory glass. The physical properties of the new material are due to the simple chemical composition—high silica content and freedom from heavy metals. Water in both thick and thin dishes of this glass exposed to 70° to 90° C. oven temperatures absorbed more heat than in aluminum, tin or enameled earthenware dishes. Resistance to fracture has been studied by dropping 350-gram weights on inverted dishes of 4.3 to 5.8 mm. bottom thickness; falls of 22 to 34 in. were required to break or crack, compared with 6 to 18 in. for enameled earthenware, and 4 to 16 in. for crockery of the same or greater bottom thickness. Culinary ware has been made from this glass and shown to give more rapid baking than that made of metal or earthenware.

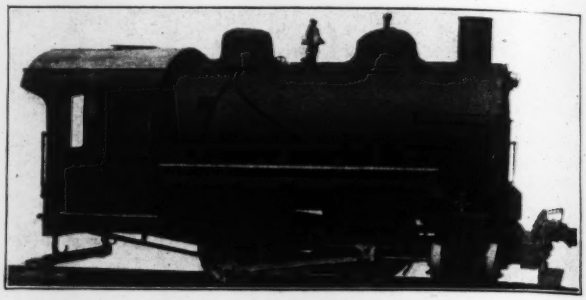
* * *

Steam-Storage Industrial Locomotives

Fireless steam locomotives, in which steam is stored under pressure in a tank taking the place of the ordinary boiler, are desirable for industrial service under certain conditions. Besides eliminating danger from fire, the engines are of comparatively low cost and easy to operate. The illustration shows one of three steam-storage engines built for the National Cash Register Co. by the Lima Locomotive Corporation, of Lima, Ohio.

It is a 38-ton, four-wheel, standard-gage engine, with 29,720 lb. tractive power and a factor of adhesion of 7.9. It has 36-in. wheels and a 6-ft. wheelbase, and is driven by 18-in. cylinders. The large cylinder diameter enables the engine to run to the charging station under very low pressure.

The tank is 7 ft. in diameter and 16 ft. long, clothed with 2 in. of magnesia insulation under the steel jacket. Three



STEAM-STORAGE INDUSTRIAL LOCOMOTIVE

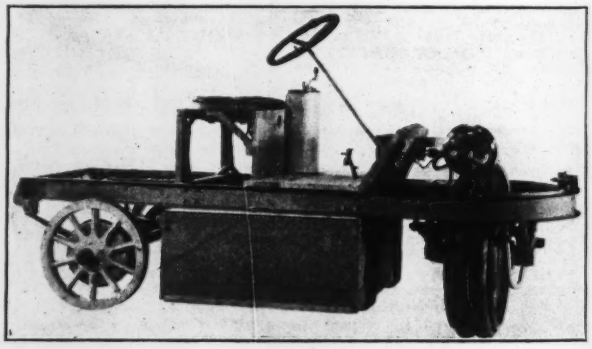
baffle plates with small openings prevent surging of the water, and at the bottom is a 2-in. perforated pipe for charging the steam. With the tank about half full of water, this pipe is connected to the boiler plant and steam forced in under 200-lb. pressure until the pressure in the tank is about 150 to 160 lb. The pressure in the cylinders is reduced to about 60 to 65 lb. by a reducing valve.

A small storage battery supplies current for the headlight. The bell ringer, sand feed and emergency brake are operated by compressed air from tanks which are charged at the power plant. A handbrake is used for ordinary work. The engines operate on about 2 mi. of track.

* * *

A Tractor with One-Wheel Drive

An electric three-wheel tractor, designed to replace team haulage where possible, has been placed on the market by the Couple-Gear Freight-Wheel Co., of Grand Rapids, Mich. The tractor is approximately the length of a team and wagon and can be turned in less space (see view). The motor is contained in and inclosed by the forward wheel and is held rigidly between the steering forks, so that the wheel revolves around the motor. On each end of the motor shaft is a small



TRACTOR WITH SINGLE-WHEEL DRIVE

pinion which engages with a circular rack fastened inside the rim. Tractors of this general design have been ussed to haul lumber from mill to yard and have given good service. The loads, of 3 to 5 tons, were hauled on planking.

In producing a tractor for general freight haulage, the manufacturer proposes that one tractor be used in connection with two wagons—one wagon being loaded while the other is being delivered and unloaded. The Radcaw Lumber Co., of Stamps, Ark., states that on May 1, 1915, it replaced 15 mules and drivers with three tractors. Once a day 15 min. is spent in oiling the machines, and at night the batteries are charged, 4 hr. being required for this operation.